OCS

OUTLET CASSETTE SYSTEM

User Manual

Version: 2, AUG/15

Designed and manufactured in Australia by Ampcontrol Pty Ltd

AMPCONTROL®

WARNING!

The **warning** symbol highlights a potential risk of **injury or death**.

Please share these warnings with other operators.

CAUTION!

The **caution** symbol highlights a potential risk of **damage to equipment**.

Please share these cautions with other operators.

NOTE

The **note** symbol highlights **key information**.

Please share these notes with other operators.

ENVIRO

The **enviro** (environmental) symbol highlights areas which may have an impact on the surrounding **fauna and/or flora**.

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Before You Begin

Thank you for purchasing the Ampcontrol Outlet Cassette System.

WARNING!

In the interests of **safety and correct equipment operation**, please take the time to read and understand the content in this manual.

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DEFINITIONS

Table 1: Definitions

Term	Definition
Cassette	A Cassette is the unit that is installed within Outlet Cassette System (OCS) or Fixed Cassette System (FCS). There are two types: FCS Cassettes and OCS Cassettes. Each Cassette houses a Protection Module, phase current transformers and main contactor components.
CB	Circuit Breaker; Main circuit breaker that controls power to all outlets.
CBR	Circuit Breaker Relay; power relay within the Cassette Protection Module to control the supply to the circuit breaker coil. The Protection Module's CBR output is designed for use with under voltage tripping coils.
FCS	FCS is the acronym for the Ampcontrol Fixed Cassette System.
MC	Main Contactor; the main power circuit opening device. Installed within the Cassette, the main contactor is opened and closed in order to turn the outlet on and off.
MCR	Main Contactor Relay; power relay installed within the Cassette Protection Module to control the supply to the main contactor coil. All trip times specified are to the opening of the MCR.
OCS	OCS is the acronym for the Ampcontrol Outlet Cassette System
Parameter Dongle	A small memory device which is used to store setting information for the MEM and RTX modules which is attached to the wiring harness of the installation.
Protection Module	The Protection Module is installed in each Cassette, providing a host of protection functions for the outlet.
RTX	Remote Termination Device; Module that is installed at the machine end of the pilot to provide machine identification and communications.

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1 SAFETY AND OTHER WARNINGS

For safety reasons, the OCS must be installed, operated and serviced only by competent personnel. Please read and understand this instruction manual completely before installing, operating or servicing this equipment. Failure to install or operate this instrument in accordance with the instructions contained in this manual may create hazardous operating conditions.

1.1 Safe Use of Equipment

The equipment supplied has been designed and manufactured to ensure safe operation. The equipment must only be used within the design parameters.

The instructions within this manual must be observed as an aid towards achieving the safest possible installation.

Persons responsible for installation, maintenance, or operation, must observe the following instructions:

1.1.1 Changes to Equipment

Changes in the design and modifications to the equipment are not permitted. Unauthorised changes made to the hardware or operating firmware will void the manufacturer's warranty, and may compromise the integrity of the system into which it is installed and other connected equipment.

1.1.2 Equipment Knowledge

Experience with, or understanding of, this equipment is essential for the safe installation and removal of the equipment. Therefore, please read and understand this manual prior to use. Competency based training courses are recommended and are available on request.

1.1.3 Manual Handling

Precautions have been taken to ensure all equipment is safe to handle and free from sharp edges. However care should always be taken when handling enclosures and gloves should be worn.

1.1.4 Installation

Correct operation and safety depend on the OCS and associated equipment being installed correctly. Mechanical and or electrical installation and maintenance of plant and equipment must only be carried out by appropriately qualified personnel and must be tested thoroughly prior to operation.

1.1.5 Operation

As safety depends on the OCS functioning correctly it is highly recommended that all safety functions of the OCS be periodically tested to ensure correct operation.

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1.1.6 Certification

WARNING!	To comply with the **Conditions of Certification**, ensure full serviceable life of the product, and avoid nullifying the warranty, it is essential to exercise great care with the installation, use and storage of the system components. Failure to comply with the Conditions of Certification may seriously compromise the integrity of the system and/or its components, and the consequence could be fatal. The user must ensure that the "Special Conditions" outlined in the certificate and associated attachment is met or the certificate (and the I.S. rating) will not be valid.

- Refer to the relevant section of the safety file for copies of certificates of conformity outlining the special conditions of the certification for the explosion protected equipment or components.
- The latest certificate and its associated attachments outlining the special conditions of the certification are maintained and available on the IEC Ex Website: http://iecex.iec.ch.

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2 RECEIVING AND STORAGE

2.1 Receiving

All possible precautions are taken to protect the equipment against damage or losses during shipment, however before accepting delivery, check all items against the packing list or bill of loading. If there is evidence of physical damage, notify Ampcontrol immediately.

Notify Ampcontrol immediately in case of any discrepancies to the packing list. Keep a record of any claims and correspondence. Photographs are recommended.

Where practicable do not remove protective covers prior to installation unless there are indications of damage. Boxes opened for inspection and inventory should be carefully repacked to ensure protection of the contents or else the parts should be packaged and stored in a safe place. Examine all packing boxes, wrappings and covers for items attached to them, retain and store any approval documentation for your safety file as applicable prior to wrapping being discarded.

2.2 Inspection

Equipment that is found to be damaged or has been modified away from its published specification must not be used. Please contact Ampcontrol if the equipment is suspected to be different than that ordered or if it does not match the published specifications.

2.3 Storage after Delivery

When the equipment is not to be installed immediately, proper storage is important to ensure protection of equipment and validity of warranty.

All equipment should be stored indoors between 0-40˚C, preferably on shelves and protected from moisture and sunlight.

2.4 Unpacking of Equipment

The method of packing used will depend on the size and quantity of the equipment. The following cautions should be interpreted as appropriate.

CAUTION!

Take care when unpacking crates as the **contents may have shifted during transport**.

ENVIRO

The disposal of packaging materials, replaced parts, or components must comply with environmental restrictions without polluting the soil, air or water.

Ensure that any timber and cardboard used as **packaging is disposed of in a safe and environmentally responsible manner**.

Where possible, dispose of all waste products i.e. oils, metals, plastic and rubber products by using an approved recycling service centre.

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3 PRODUCT OVERVIEW

The Ampcontrol Outlet Cassette System (OCS) is a major advancement in control and protection technology. The OCS combines the outlet contactor, protection module, current transformers and outlet test circuitry into a single replaceable unit. This has the advantage of resulting in minimal down-time in the event of a fault.

The Ampcontrol OCS is available in two types: the standard OCS and the Fixed Cassette System (FCS).

The OCS provides isolation and earthing of individual outlets via integrated actuators that are controlled at the touch of a button via a Human Machine Interface (HMI) screen. In this manner, operators are not exposed to potential electric shocks resulting from residual static charge on the cable. This also eliminates a potential ignition source of an explosive atmosphere.

Figure 3.1: Ampcontrol Outlet Cassette System (OCS)

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The FCS (1.1kV systems only) sacrifices the remote isolation and earthing functionality of the OCS to provide a higher outlet density. Due to the compact nature of the FCS, 10 outlets are able to be installed in the same area used by a conventional 8 outlet system. The FCS is designed as a fully bolted, non-withdrawable installation, whilst still minimising downtime by providing fast and easy removal of the cassette protection components.

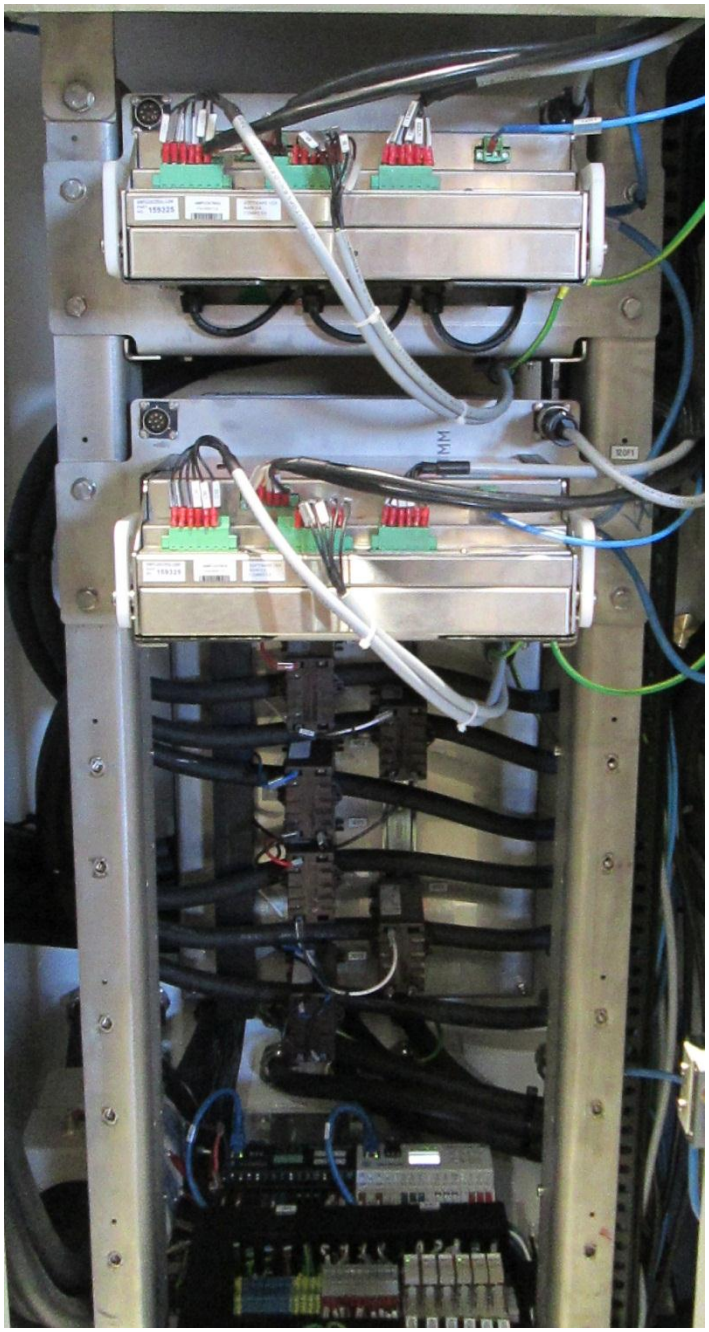

Figure 3.2: Ampcontrol Fixed Cassette System (FCS)

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Key Features:

- Individual outlet isolation and earthing system (OCS)
- Operations via HMI interface
- Ethernet communications
- Cassette Protection Module

All electrical protection functions are provided by the new generation Cassette Protection Module and include:

- Earth Leakage
- Earth Fault Lockout
- Earth Continuity (including remote start mode)
- Contactor Failure protection
- Motor thermal overload protection
- Short circuit protection
- Under current protection
- Current balance protection
- Under voltage protection
- Automatic HV insulation test prior to outlet closing
- Machine identification.

The following Control and Monitoring functions are accessed via the Ethernet/IP communications:

- Monitoring of key parameters for all protection functions
- Protection settings and parameter adjustments
- Statutory tests
- Resetting of protection trips
- Outlet control (starting and stopping)
- The status of all protection functions and control logic.

All control of outlet(s) is from the HMI screen.

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4 INSTALLATION

4.1 General Warnings

These instructions have been designed to assist users of the OCS with installation.

Before the OCS can be installed, there are a number of things that need to be considered and understood to prevent incorrect or unsafe operation of the OCS or the system into which it is installed.

Along with relevant competence, and an understanding of the target application, the following points should be considered:

4.1.1 Ensure that the information provided in this user manual is fully understood.

It is extremely important that the limitations and functionality of the OCS are understood to prevent incorrect installation and use from creating a potentially dangerous risk. If in doubt as to the nature of the limitations or their implication, refer to the installation's safety dossier or consult a competent authority such as a supervisor or Ampcontrol technical representative.

4.1.2 Ensure that the application into which the OCS is being installed has been properly defined, designed and approved.

Any system intended to mitigate the risk of injury needs to be properly designed and implemented. Such a system must be the result of structured risk analysis with the outcomes used to define the system requirements. These requirements, in turn, will guide the choice of instrumentation, logic solvers and actuators needed to implement the system. Understanding the needs of the system will ensure proper selection of equipment.

4.1.3 Ensure that the OCS will properly perform the required functions within the system design.

It is important to understand how the OCS is intended to interact with other equipment within a system. For safe and reliable use, it is crucial that neither the OCS's logical operation nor its signalling be compromised by incompatibilities with connected equipment.

4.1.4 Modifications of any form to the OCS are prohibited.

The OCS as supplied has been designed and manufactured to comply with the requirements of protection standards. If modifications of any form are made to the OCS, the equipment may no longer be fit for purpose. If any modifications or damage to the OCS is evident, do not use the equipment and contact Ampcontrol for advice.

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4.2 Mandatory Installation Practices

The following information must be adhered to when installing the OCS. Failure to adhere to this information may give rise to unsafe operation.

Using the OCS in a manner that exceeds its electrical, functional or physical specifications, or in a way that is contrary to its operating restrictions, may create risks to personnel and/or equipment resulting in injury or death.

- The OCS is to be installed in an electrical system having a fault level equal to or less than as marked on the name plate.
- The OCS's control supply must remain within the specified voltage range.
- The installation of the OCS must be carried out by suitably trained and qualified personnel.
- Identification labels fixed to the OCS must not be damaged, removed or covered.
- The installation is to be in accordance with the relevant installation Standards/Codes of Practice.
- Modifications must not be made to any part of the OCS. As supplied, the unit is built to, and complies with the relevant standards. Modifications to its construction will render the unit non-compliant.
- Complete and accurate records of the installation must be kept as part of the site installation.
- The equipment is to be maintained as per the conditions as listed in the certification documentation.

NOTE

If the OCS is to be used in a hazardous environment, it must be installed within suitably certified flameproof enclosure.

NOTE

The equipment is to be operated within an ambient temperature range of - 20°C to + 40°C.

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4.3 Mechanical Arrangement

4.3.1 OCS Dimensions

The OCS is available in two sizes: the 2-Way OCS and the 3-Way OCS. These modules are designed to be stacked on top of each other, allowing the best utilisation of the installation area.

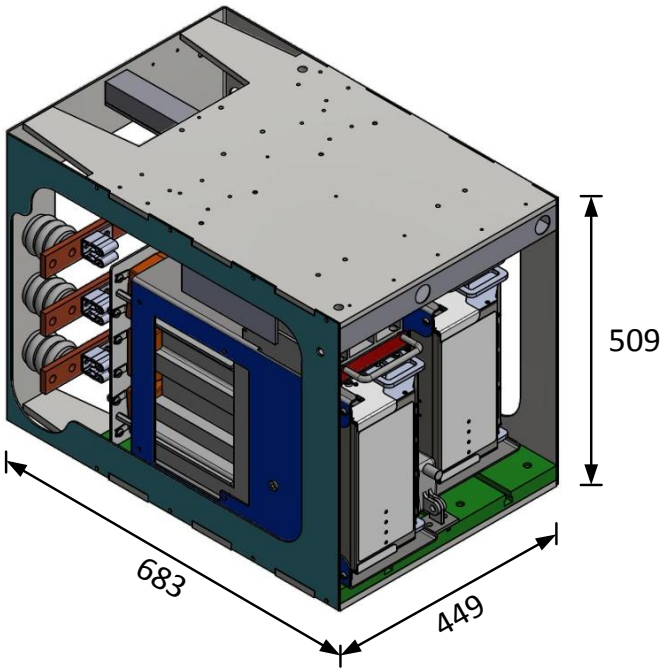

Figure 4.1: 2-Way OCS Dimensions (Pictured with 2 Cassettes Installed)

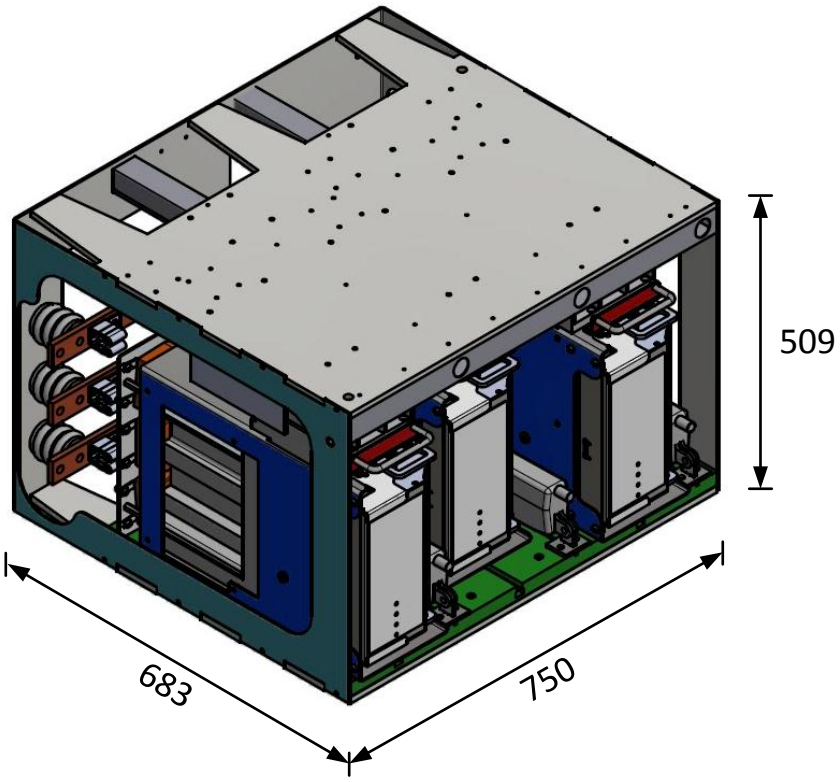

Figure 4.2: 3-Way OCS Dimensions (Pictured with 3 Cassettes Installed)

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4.3.2 FCS Dimensions

The FCS has a very high outlet density, allowing more outlets to be installed with a smaller footprint.

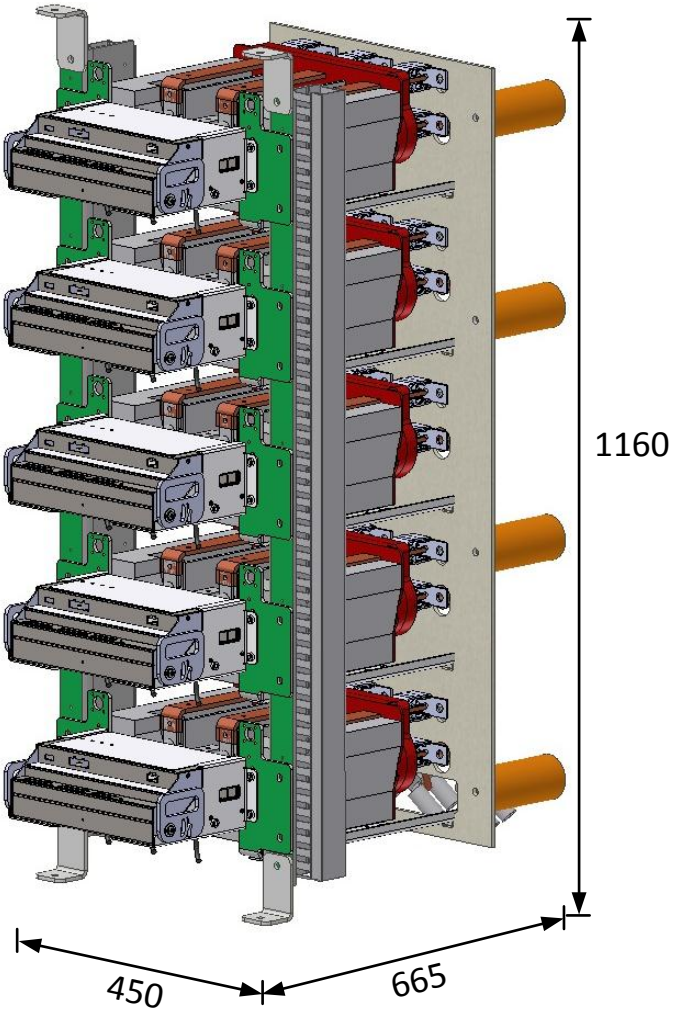

Figure 4.3: FCS Dimensions (Pictured with 5 Cassettes Installed)

4.4 Electrical Installation Information

Refer to drawing IPXE002 in Appendix B for electrical installation information.

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4.5 External Accessories

4.5.1 Earth Leakage CT

The Outlet Cassette Protection Module uses an Ampcontrol EL500 series current transformer for earth leakage measurements. For the purposes of outlet identification tests during operation, the earth leakage toroid is installed separately to the Cassette.

4.5.2 Remote Termination Unit (RTX)

The RTX is a microprocessor based module that replaces the diode at the end of the pilot conductor of the trailing cable. It is powered by and communicates via the pilot line. Its non-volatile memory stores the parameters to configure the outlet as appropriate for the connected machine. The RTX Module is pictured in Figure 4.4.

All terminals are fully shrouded, with the pilot and earth terminals being segregated from the other terminals.

The RTX provides remote start and stop facilities. The circuitry involved in these functions is self-diagnostic and will cause the outlet to turn off if the circuits are earthed or interconnected. This reduces the chance of the outlet operating when not required to do so due to wiring faults. It should be noted that these functions are operational only, and that any emergency stops should be wired direct into the pilot circuit.

PTC terminals are provided for a semiconductor ‘switching’ thermistor. These terminals are protected in a similar manner to the stop and start circuits. If the remote start, stop and PTC functions are not required, each set of terminals must be bridged in order to start the Protection Module.

Five RTD inputs are provided for PT100 RTDs. These terminals can also be used with resistor networks to provide digital information back to the Cassette Protection Module.

A parameter dongle allows an RTX to be replaced without needing to re-program the parameters. When installed, this dongle should be firmly secured to the machine/equipment.

Figure 4.4: Remote Termination Unit (RTX)

4.5.3 Parameter Dongle

Parameters important to the running of the Protection Module and the safe operating of the outlet onto which it is connected are stored in the Protection Module Parameter Dongle. The Parameter dongle is exchangeable between Protection Modules, but it is intended to be physically tethered to the outlet that it controls.

Although the Protection Module and the RTX use the same hardware parameter dongle the parameters they store are different. As such the parameter dongle is not interchangeable between the Protection Module and RTX.

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5 COMMISSIONING AND CALIBRATION

Prior to being put into service, the electrical protection system must be correctly commissioned. This manual does not cover system commissioning; the full scope of commissioning tests should be determined during the risk assessment or FMEA covering the design of the electrical protection system.

The following test can provide guidance on checking the correct operation of the Cassette Protection Module during commissioning. These tests should be performed on each individual Cassette within the installed OCS.

This is not intended to provide an exhaustive commissioning checklist, but should be considered to be a minimum set of tests.

5.1 Earth Leakage

Test the correct operation of earth leakage circuits by injecting a fault current through the Earth Leakage CT. Ensure that all relevant tripping circuits operate successfully and that latched trips may be reset in the appropriate manner.

Disconnect the toroid from the Cassette Protection Module and ensure that an EL CT fault trip is issued with similar effect.

5.2 Earth Fault Lockout

Test the correct operation of Earth Fault Lockout protection by connecting suitably rated test resistors to the power conductors. Attempt to energise the outlet and confirm that the Cassette Protection Module trips on Earth Fault Lockout.

WARNING!

If the Earth Fault Lockout does not trip during this test, **full system voltage and power may be subsequently applied to the test resistors**.

5.3 Earth Continuity

Test that the Earth Continuity protection is operational by creating an open circuit on the pilot conductor. Ensure that all relevant tripping circuits operate successfully and that latched trips may be reset in the appropriate manner.

Repeat with a short circuit between pilot and earth.

These tests can be facilitated using earth continuity test relays, built into the Cassette Protection Module. These relays are controlled using the Cassette Protection Module's communications interface.

5.4 Insulation Test (High Voltage)

If the Earth Fault Lockout and Earth Continuity tests are successful, check that an automatic HV insulation test is initiated by the Cassette Protection Module when the module is started.

WARNING!

During this test the **Cassette Protection Module will generate up to 2700VDC** from the 24 VDC input supply **and apply this voltage to the phase conductors**.

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5.5 Over Current/Motor Overload Current Injection

Test the Over Current/Motor Overload protection by carrying out secondary/primary injection on the CT inputs of the Cassette Protection Module.

Inject 2x Full Load Current (FLC) into one of the CT terminals and ensure that all relevant tripping circuits operate successfully, in the time expected according to the settings employed, and that latched trips may be reset in the appropriate manner. Repeat on the other CT terminals.

5.6 Short Circuit Current Injection

Test the Short Circuit protection by carrying out secondary/primary injection on the CT inputs of the Cassette Protection Module.

Inject a current value relevant to the settings employed into one of the CT terminals and ensure that all relevant tripping circuits operate successfully, in the time expected, and that latched trips may be reset in the appropriate manner. Repeat on the other CT terminals.

5.7 Main Contactor Fail

While the Cassette Protection Module is stopped (that is, the MCR output is open), apply a voltage on the load side of the contactor. The voltage must be greater than the selected trip level. Ensure that a CBR trip is initiated by the Cassette Protection Module.

NOTE

A Main Contactor Fail (MCF) trip can only be reset by pressing the MCF Reset Pushbutton on the front of the Outlet Cassette's Protection Module.

While the Cassette Protection Module is stopped, close the MCI digital input. Ensure that a CBR trip is initiated by the Cassette Protection Module.

5.8 Voltage Measurement

Validate the voltage measurement function of the Cassette Protection Module by checking the measured voltages via the PLC when the main contactor is closed.

5.9 RTX

Validate the correct operation of the RTX by making changes to load parameters, moving the machine to a different outlet and ensuring that the correct settings are available on the new outlet.

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6 PRODUCT OPERATION

6.1 Outlet Control

In a typical installation, the outlet contactor is directly controlled by the Protection Module. The supervising PLC will send commands to the Protection Module to start or stop the outlet. The Protection Module will respond by controlling its MCR output accordingly. In the event of any trip condition occurring, the Protection Module will open the MCR output (or CBR output as appropriate) and prevent reclosing the output until the fault condition has cleared and the trip has been reset.

To close an outlet controlled by a Protection Module, the supervising PLC will send a start command. The following start sequence will be followed:

- If there are any active trips, the Protection Module will ignore any start command received
- If all trips are cleared and the Protection Module will initiate a start sequence
- An earth fault lockout test is conducted. This test checks for a cable fault to earth. The test voltage and current are limited to intrinsically safe levels. If the test fails, the start sequence will be cancelled and the Protection Module will report an earth fault lockout trip.
- If the earth fault lockout test passes, the Protection Module may then conduct an optional high voltage DC insulation test on the cable. If the insulation test fails, the start sequence will be cancelled and the Protection Module will report an insulation test trip. The insulation test can also be disabled via parameter settings.
- If the insulation test passes, the start sequence moves to the closing state and the MCR output will be closed.
- The Protection Module now waits for the MCI digital input to close. This auxiliary feedback from the signal confirms that the main contactor has closed. If the MCI does not follow the MCR within five seconds a ‘close fail’ trip will occur and the start sequence will be cancelled.
- If the MCI digital input closes, the Protection Module moves from the start sequence to the running state. It will continue in the running state with the outlet closed until a stop command is received or any protection function trips.
- If at any point during the start sequence a stop command is received or a protection function trips the start sequence is immediately cancelled and the MCR (or CBR if appropriate) output will be opened.

6.2 Control of Resets

All trip resets in the Protection Module are handled by positive edge reset signal events. In this way continually driven reset signals will not reset faults. Most trips are reset with a general reset. Some trips have a dedicated reset, to allow selective control of the reset functions and to provide a level of authority associated with resetting faults. The trips that require additional reset commands include the Earth Leakage, Thermal Memory for motor overload protection and Short Circuit.

Main Contactor Failure events generate a trip that cannot be reset by the PLC. These trips require an inspection of the switching equipment associated with the outlet controlling Protection Module and as such the reset is provided by way of a push-button, accessible from the front of the Protection Module.

6.3 Internal Trips

The Protection Module has a number of trip functions that are not directly associated with the protection of the outlet, but signal that other dangerous faults have been detected.

6.3.1 CCM ID

The Protection Module has an internal detection circuit to identify the CCM module that is assembled within the Cassette. If the CCM identity fails to match with that which is expected, the Protection Module will set this trip. There is currently one CCM version which is used for both 1100V and 3.3kV outlets. If this trip occurs the Cassette should be returned for repair.

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6.3.2 MCF Battery Trip

The Protection Module has an internal battery. This is used to power the real time clock (used to timestamp log messages) as well has power the main contactor fail latch. The health of this battery is monitored and if the battery condition is failing this trip will be set. If this trip occurs the Protection Module should be returned to have the battery repaired or replaced.

6.3.3 Internal Logic Error

This trip will be set in the event that an internal fault has been detected. If this trip occurs the Cassette should be returned for repair.

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6.4 Events Log

A real time clock/calendar is included in the Protection Module. This combines with the non-volatile memory to provide a data-logging feature. This log sequentially records the time, date and details of the most recent event. A chronological list of the previous 50 events is stored.

The following events are logged:

Table 2: Event Log Entry Types

Event ID	***String***	***Description***
0	*Unused*	Not a valid Message. Should not be seen.
1	Feed On	Logs the Machine Type (Data1) and Machine Number (Data2) when the main contactor has been closed while in RTX mode.
2	Insulation Test Record	The results of an automatic HV insulation test.
3	Earth Leakage Trip	Earth leakage current was measured above the selected trip level.
4	Series Earth Continuity Trip	The series resistance of the pilot was measured to be above the selected trip level.
5	Over current\Overload Trip	The currents exceeded the bounds of the selected trip characteristic.
6	Short Circuit INST Trip	An Instantaneous Short Circuit trip occurred.
7	Close Failed	After being requested to close, the Main Contactor has not closed within 5 seconds. (As detected via the MCI)
8	Main Contactor Relay Closed	The main contactor relay was closed.
9	Under Current Trip	Phase currents were measured to be below the selected trip level.
10	General Trip Reset	A Trip was cleared via a General Reset request.
11	Power Down	The system has been powered down correctly.
12	Protection Module Dongle Parameter Error	There was an error with the Protection Module parameter dongle.
13	Unexpected Restart	The MEM Processor restarted without a clean power down (most likely due to the watchdog resetting the system.)
14	Frozen Contactor	The MCI Detects the contactor is closed while the Main Contactor is requested to be open. This is a type of MCF Trip, and will also have a Main Contactor Failure event log as the next log message.

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Event ID	String	Description
15	Loss of Vacuum	Voltage was detected at the outlet while the Main Contactor was open. This is a type of MCF Trip, and will also have a Main Contactor Failure event log as the next log message.
16	Current Balance Trip	The difference between the measured phase currents is greater that the selected trip level.
17	Thermal Memory Loss	The system was unable to read the Thermal Memory value from Battery Backed up Ram while booting. The Motor Overload value will be initialised to 100%.
18	Main Contactor Opened	The main contactor auxiliary contact opened while in run mode.
19	RTX Parameter Error	There was an error with the RTX parameter dongle.
20	Shunt Earth Continuity Trip	The resistance of the pilot to earth was less that the trip level.
21	Thermal Memory Reset	The thermal memory was overridden by user intervention & reset to zero.
22	RTX Stop	The RTX stop input was activated causing an outlet stop.
23	RTX Offline	The RTX went offline causing an outlet trip.
24	Insulation Trip	The pre-start high voltage insulation test failed.
25	RTX Comms Timeout	RTX is online, but there was repeated data corruption.
26	Power Up	The system has powered up after a clean power down.
27	Under Voltage Trip	The phase voltage dropped below the trip level causing the outlet to drop out of run mode.
28	Stopped	General log denoting when the system completed the request to drop out of run mode.
29	No Coil Voltage Trip	Logs when a ‘No Coil Supply’ trip occurred.
30	CT Detection Error	The earth leakage system could not detect an adequate toroid connection.
31	Remote Start Stuck	The remote start button was detected to be closed for longer that the trip limit.
32	PLC Comms Timeout	The PLC failed to provide ‘heart beat’.
33	Start Disabled	The Protection Module was disabled by the PLC
34	Earth Fault Lockout Trip	The resistance measured between the phases and earth during an intrinsically safe EFLO test was below the set level.

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Event ID	*String*	*Description*
35	Unknown Restart Status	The system has powered up, but cannot work out if the system powered down cleanly or if it had a restart.
36	Short Circuit Trip Reset	A short circuit trip was reset.
37	Earth Leakage Trip Reset	An earth leakage trip was reset.
38	Fatal Clock Error	The clock time was not able to be read from the Real Time Chip.
39	MCF Battery Under Voltage	The Battery which stores the Main Contactor Failure state and powers the Battery Back Ram is under Voltage (eg the battery has reached the end of its life)
40	Control Mask Changed	Notes that the value of the control mask has been changed (eg a Test Relay has been closed.) Data1 stores the old mask value; Data2 stores the new mask value.
41	Invalid CCM	Logs the fact an invalid CCM was attached to the Protection Module. This is the logged version of a 'CCM ID' trip.
42	Internal Logic Error	An Error has occurred in the operation of the code within the Protection Module. The log is used to denote that the stack has grown too big or that the system has run out of RAM. In normal operation neither of these things should occur.
43	PTC Trip	The outlet was stopped due to the RTX's PTC input exceeding its trip resistance level.
44	RTX RTD Group 1 Trip	The outlet was stopped due to one of the RTD inputs within group 1 going above the set trip level
45	RTX RTD Group 2 Trip	The outlet was stopped due to one of the RTD inputs within group 2 going above the set trip level
46	Short Circuit LT Trip	Short Circuit 'Long Time' tripped.
128 - 218	Parameter Modified.	To work out which parameter was modified, minus 128 from the Event ID (eg 130 means parameter 2 was modified) Outlet parameters are numbered 0-29, Dongle Load parameters are numbered 30-59 and RTX Load parameters are numbered 60-89. The value which was changed from is stored in Data1 and the new value is in Data2.

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6.5 Protection Module Parameters

There are two distinct groups of parameters:

6.5.1 Outlet Parameters

Outlet Parameters relate to the particular outlet/Protection Module. Examples include the pilot mode, outlet number and network settings. These are always stored in the Parameter Dongle.

Table 3: Outlet Parameter Descriptions

Name	***Description***
IP Address Byte 1	IP address for Ethernet communications with the PLC.
IP Address Byte 2	
IP Address Byte 3	
IP Address Byte 4	
Subnet mask Byte 1	Subnet mask for Ethernet communications with the PLC.
Subnet mask Byte 2	
Subnet mask Byte 3	
Subnet mask Byte 4	
Gateway Address Byte 1	Gateway address for Ethernet communications with the PLC.
Gateway Address Byte 2	
Gateway Address Byte 3	
Gateway Address Byte 4	
Pilot mode	Selects the pilot termination method; diode or RTX.
Loss Of Vacuum Level	Trip level for loss of vacuum protection.
Voltage Level	Defines the system voltage level.
SC Output Relay	Selects which output relay the short circuit trips.

6.5.2 Load Parameters

Load Parameters relate to the properties of different loads that may be connected to the Outlet Cassette. Examples include the motor current, EC trip latch, and remote control. Load parameters can be stored in either the RTX (if present) or the Parameter Dongle.

NOTE

Parameters cannot be changed while the Protection Module is running.

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Table 4: Load Parameter Descriptions

Load Parameter Name	***Description***
Load Machine Type	Text describing the type of machine. (RTX only)
Load Machine ID	Number identifying the machine. (RTX only)
Full Load Current Range	Defines the full load current the Protection Module expects to see. This determines the scaling of current readings, the base current for motor overload or inverse time over current protection and the trip levels for short circuit protection.
Short Circuit Trip Level	Defines the short circuit trip level as a multiple of the full load current setting.
Short Circuit Trip Time	Determines how long the current reading needs to be above the trip level before the Protection Module trips.
Over Current Curve	Selects if the over current protection will use one of the inverse current-time curves or thermal motor protection curve. This selection also impacts the short circuit functionality.
Over Current Time Multiplier (TMS)	Determines the trip time characteristic for Over Current/Motor Overload.
Over Load Cooling Multiplier	Defines the cooling output of the thermal model, when thermal motor protection is selected.
Over Load Start Block Level	The thermal accumulator must be below this value to allow an outlet start.
Current Balance Trip Level	Selects the trip level for or disables current balance protection
Under Current Trip Level	Selects the trip level for or disables under current protection
Earth Leakage Trip Level	Selects the trip level for earth leakage protection
Earth Leakage Trip Time	Selects the maximum trip time for earth leakage protection
Earth Continuity Trip Level	Selects the nominal series earth continuity trip level
Earth Continuity Trip Time	Selects the maximum trip time for both series and shunt earth continuity protection
Earth Continuity Latch	Selects whether earth continuity trips are latch (requiring general reset) or automatically reset when healthy
Remote Start	Enables remote start of the outlet via the pilot signal. When the pilot is set to diode mode, the remote start function uses a 100Ω series start resistor. When remote start is enabled, the PLC will not be able to initiate a start.
Insulation Test Trip Level	Selects the trip level for or disables the automatic insulation test.
Under Voltage Trip Level	Selects the trip level for or disables under voltage protection
Back EMF Time	Selects the back EMF timer period which inhibits loss of vacuum detection after the outlet is opened.

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6.6 Time and Date

The time and date are used only to time stamp the events in the log (which are recorded sequentially regardless of the time and date). The time and date are not used for any control functions.

6.7 Cassette Isolation & Earthing (OCS Only)

Through the use of remotely controlled actuators, the OCS allows individual Outlet Cassettes to be moved between the service and earth positions. This provides both a break between the outlet phase conductors and the incoming supply, as well as visual earthing of the outlet cable without the requirement of a separate earthing outlet.

Each Cassette houses the line and load contacts, vacuum contactor, three current transformers and the Protection Module. The cassette is driven between the service and earth positions by an electrically driven actuator. When in the service position the cassette is connected to the line and load contacts with the on-board vacuum contactor switching the outlet. In the earthed position the cassette is disconnected from the line bus and connects the load connections to earth. These earth contacts are visible through viewing windows.

When in the earth position the supply to the actuator can be externally isolated to prevent operation to move the cassette away from the earth position.

6.7.1 Actuator

Actuators are used to transition the cassettes between the service and earth positions. The actuator is controlled via PLC outputs and provides 'actuator healthy' feedback to the PLC. An analogue input corresponding with the position of the actuator rod is compared with the state of the limit switches by the PLC to indicate the position of the cassette.

NOTE

Each actuator has a **coloured band on each end of the cable** to denote actuator **position within the chassis** (as shown in Figure 6.1).

Non matching colours will prevent operation of the actuator.

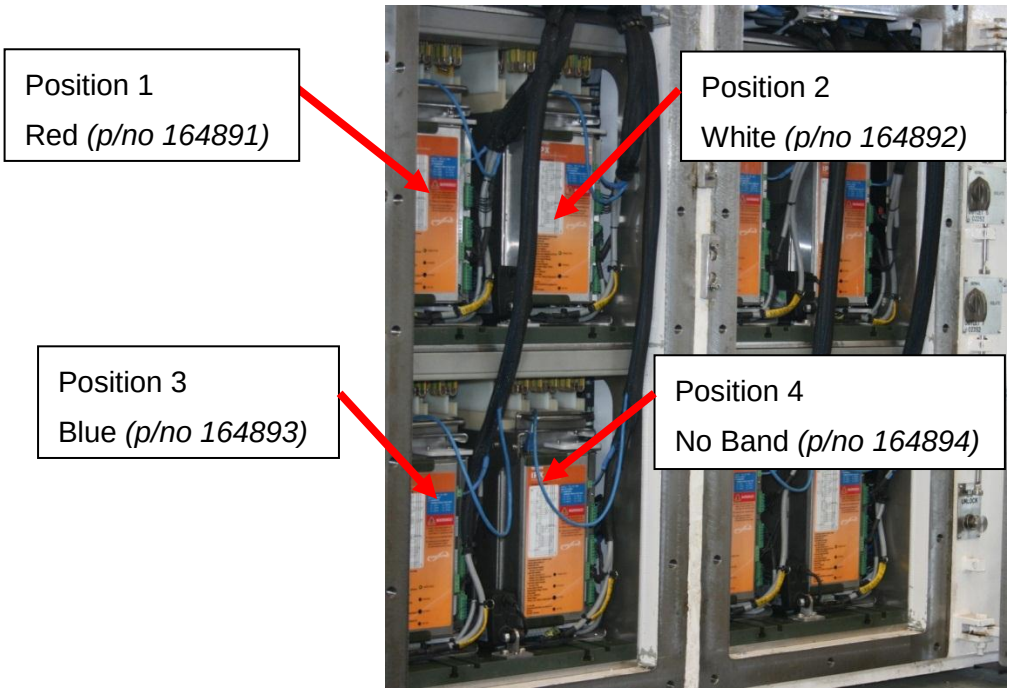

Figure 6.1: Actuator position within chassis

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7 AS/NZS 2081:2011 PROTECTION FUNCTIONS

The Protection Module, housed within the Cassette, provides a number of protection functions that meet the requirements of the AS/NZS 2081:2001 standard. This protection functions are:

- Earth Leakage
- Earth Continuity
- Earth Fault Lockout
- Main Contactor Fail

7.1 Earth Leakage

7.1.1 Trip Characteristics

Table 5: Protection Module - Earth Leakage Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	Requires an earth leakage reset after the trip condition has cleared
Trip Actions	Open Main Contactor Prevent Main Contactor from closing
Active Period	Always active
Logging	Always logged
Parameters	Trip Level Trip Time
Monitoring	Earth Leakage current displayed as 0-150% of selected trip level

7.1.2 Operation Summary

The earth leakage protection function uses an Ampcontrol EL500 series toroid to measure the earth fault current. This function is tested to AS/NZS 2081:2011. A definite time operating characteristic is provided with adjustable trip sensitivity and an adjustable time delay.

NOTE

Due to size restrictions and the coupling issues related with elongated current transformers, the Ampcontrol EL500 series earth leakage toroid is **not integral to the Cassette** and must be **purchased separately**.

When a fault occurs such that the trip level and time delays are exceeded a trip occurs. The trip acts in the Main Contactor Relay (MCR) logic and is latched. An earth leakage trip is considered a special fault and requires a specific reset function to be cleared.

The leakage current (EL) is displayed as a % of the trip level. When the leakage reaches 100% for the selected time delay a trip occurs.

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7.1.3 Earth Leakage CT Failure Protection

Table 6: Protection Module - Earth Leakage CT Failure Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	Requires a general reset after the trip condition has cleared
Trip Actions	Open Main Contactor Prevent Main Contactor from closing
Active Period	Always active
Logging	Always logged
Parameters	None (Trip time and level is fixed)
Monitoring	CT Detect trip status bit

The Protection Module generates a CT Detection Signal to test the integrity of earth leakage circuit. The CT Detection signal continually tests the earth leakage current transformer, the wiring loop to the transformer and the input to the protection relay as required by AS/NZS 2081: 2011.

The signal is fed from Pin 6 of the Protection Module. Pass one loop through the earth leakage current transformer then back to Pin 7.

The Earth Leakage CT Failure trip time is fixed at 500ms.

NOTE

The **loop resistance** of the CT Detection Signal circuit must remain **below 1Ω**.

7.2 Earth Continuity

The earth continuity function tests for the continuity of the earth between the outlet and the machine, via the pilot in the trailing cable. This is in accordance with AS/NZS 2081: 2011. The pilot is also used to transfer data when a remote termination unit (RTX) is used to achieve machine communication.

The Cassette Protection Module can be configured to operate in either diode or RTX mode. This determines what terminating device the relay is looking for on the pilot.

NOTE

The RTX will only be recognised by the Cassette Protection Module and will **not be seen as a diode by other earth continuity devices**.

CAUTION!

Cable parameters are important to the correct operation of the Pilot E/C function. Resistance & capacitance values can **determine the length of cable that the relay can drive**.

The relay measures the resistance of the pilot - earth loop and the leakage between the pilot and earth

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conductors. These measurements are known as the series earth continuity resistance and the shunt earth continuity resistance, respectively. The shunt measurement ensures that a pilot to earth fault is detected. If the pilot - earth loop is not healthy (series resistance greater or shunt resistance lower that their respective trip settings) a trip occurs which in turn opens the main contactor control circuit.

The trip can be configured as latching or non-latching. This allows the user to determine if the trip is manually or automatically reset once the pilot - earth loop is healthy.

7.2.1 Pilot Series

Table 7 Protection Module - Earth Continuity Series Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	Requires a general reset after the trip condition has cleared. Alternatively the trip can be automatically reset depending on the status of the EC Latch parameter.
Trip Actions	Open Main Contactor Prevent Main Contactor from closing
Active Period	Always active
Logging	Logged only if outlet is running
Parameters	Trip time Trip level Trip latch enable
Monitoring	Available as the raw ohms measurement, resolution of 1Ω.

7.2.2 Pilot Shunt

Table 8: Protection Module - Earth Continuity Shunt Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	Requires a general reset after the trip condition has cleared. Alternatively the trip can be automatically reset depending on the status of the EC Latch parameter.
Trip Actions	Open Main Contactor Prevent Main Contactor from closing
Active Period	Always active
Logging	Always logged
Parameters	Trip time Trip latch enable
Monitoring	Available as the raw ohms measurement, resolution of 100Ω.

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7.2.3 Pilot Remote Start

Remote start mode can be used to allow the start sequence to be initiated from the load via the pilot signal. In remote start mode, the PLC cannot force the start of the outlet. It can however prevent the outlet from starting.

The remote start setting requires the following sequence for a start to be triggered:

1. All trips must be clear.
2. The PLC Comms enable bit must be enabled for a remote start condition to be possible and accepted.
3. The pilot resistance must be detected above 90Ω to ensure a start resistor is in place.
4. As soon as the resistance calculation drops below the EC series threshold a start is triggered. (Note that the EC series protection function will still be operating, and the start will not be triggered if the EC measurement is above the set threshold).
5. If the EC resistance falls below 90Ω, but remains above the EC series threshold it will result in a remote start error trip after 1 second.
6. The start sequence (EFLO, IT, MC closing) starts immediately after the trigger.
7. The start resistor must remain shorted out by the start button for the duration of the pre-start tests.
8. If the EC resistance does not return to above 90Ω within 5 seconds after the outlet closes, the Protection Module will trip on “Remote Start Stuck”.
9. After a start has been triggered, the EC resistance must return above 90Ω before another start can be triggered.
10. The Remote Start Fault is automatically reset once the EC resistance returns above 90Ω. (An external reset is not required.)

7.3 Earth Fault Lockout

The Cassette Protection Module can provide a two-step insulation test as part of the Earth Fault Lockout protection function. The initial test is the mandatory intrinsically safe test and can be followed by an automatic High Voltage ‘Insulation Test’.

7.3.1 Intrinsically Safe EFLO

Table 9: Protection Module - Earth Fault Lockout (EFLO) Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	Requires a general reset after a failed test
Trip Actions	Prevent Main Contactor from closing
Active Period	Single test performed during the start sequence
Logging	Logged when test fails
Parameters	No parameters
Monitoring	Last test value stored, for each phase. Value stored is from 0-150%, where 100% is 1MΩ (all phases in parallel).

The initial earth fault lockout function tests the resistance of the three phase lines to earth by applying an intrinsically safe signal prior to the closure of the main contactor in accordance with AS/NZS 2081: 2011. The test is initiated by starting the relay once all starting conditions are met. This test takes 2 seconds. If the value measured is less than the pre-set level a trip occurs.

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7.3.2 High Voltage Insulation Test

Table 10: Protection Module – High Voltage Insulation Test Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	Requires a general reset after a failed test
Trip Actions	Prevent Main Contactor from closing
Active Period	Single test performed during the start sequence. Optionally can be disabled.
Logging	Always logs the measured test result. Trip events are logged separately
Parameters	Trip Level
Monitoring	Last test value stored.

If an insulation trip level has been selected, an automatic High Voltage DC 'Insulation Test' is carried out after an Intrinsically Safe Earth Fault Lockout Test has been passed.

During the 'Insulation Test' the Protection Module generates a high DC voltage, approaching the peak system voltage, which is applied between each phase and earth. The Protection Module measures the voltage on the line and calculates the meg-ohm resistance to earth for all three phases. If the resistance value is above the pre-set threshold the Protection Module will close its MCR output, closing the outlet.

The insulation test takes 4 seconds.

The results of the insulation test should only be used as a guide to confirm that insulation remains above the pre-set threshold. Insulation tests apart from the generated insulation test via the Protection Module should be still carried out on a regular basis for maintenance purposes.

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7.4 Main Contactor Protection

There are four main contactor protection functions. Each of the functions monitors the states of the outlets main contactor. If a fault is detected the upstream circuit breaker is opened (via the CBR output) in order to remove power from the potentially faulty contactor.

7.4.1 Voltage Detection (Loss of Vacuum)

Table 11: Protection Module – Voltage Detection (Loss of Vacuum) Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	Requires a physical reset after a trip. The reset button is found on the front cover of the Protection Module
Trip Actions	Open Circuit Breaker Prevent Main Contactor from closing
Active Period	When outlet is not running and the Back emf timer has finished counting down
Logging	Logged when a trip occurs
Parameters	Trip Level Back emf Timer
Monitoring	Phase voltages are continuously updated.

Loss of Vacuum provides a mechanism for checking that voltage is not present on the outlet after the Main Contactor has opened. The level at which the Main Contactor Failure should be initiated for residual voltages are outlined in AS/NZS 2081:2011 Clause 9.2.1.

The Loss of Vacuum protection cannot be enabled immediately after the outlet is stopped as there is the potential for back emf from the load to cause a trip. Subsequently, a back emf timer is provided and allowed to elapse after the outlet has stopped, before the Loss of Vacuum protection can be operated. AS/NZS 2081:2011 Clause 9.3 and Appendix H cover the requirements for back emf considerations for Frozen Contactor devices where large inertial loads are connected.

The trip level can be selected at 25VAC or 50VAC. The trip time is less than 1sec.

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7.4.2 Frozen Contactor

Table 12: Protection Module – Frozen Contactor Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	Requires a physical reset after a trip. The reset button is found on the front cover of the Protection Module
Trip Actions	Open Circuit Breaker Prevent Main Contactor from closing
Active Period	When outlet is not running
Logging	Always
Parameters	No parameters
Monitoring	None

AS/NZS 2081:2011 Clause 9.2.2 states that the MC's auxiliary interlocks must be in agreement with the control signals being sent to the MC, else tripping of the upstream CB shall commence.

Frozen contactor detection is while the MCR is open. If the Protection Module detects that the main contactor has closed (or remains closed after the MCR is opened for any reason), it will result in a frozen contactor trip.

The frozen contactor protection activates in approximately 100ms.

7.4.3 Close Fail

Table 13: Protection Module – Contactor Close Fail Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	Requires a physical reset after a trip. The reset button is found on the front cover of the Protection Module
Trip Actions	Open Circuit Breaker Prevent Main Contactor from closing
Active Period	After closing MCR, prior to receiving confirmation from the MCI
Logging	Always
Parameters	No parameters
Monitoring	None

AS/NZS 2081:2011 Clause 9.2.2 states that the MC's auxiliary interlocks must be in agreement with the control signals being sent to the MC, else tripping of the upstream CB shall commence.

Close fail detects the event when the Protection Module attempts to close the output by closing its MCR output, but receives no confirmation of the close output contactor via the MCI digital input.

Close fail protection activates in approximately 1sec.

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7.4.4 External Open

Table 14: Protection Module – External Open Trip Characteristics

Parameter	***Action***
Power Cycle	Trip status maintained
Reset	Requires a physical reset after a trip. The reset button is found on the front cover of the Protection Module
Trip Actions	Open Circuit Breaker Prevent Main Contactor from closing
Active Period	While running
Logging	Always
Parameters	No parameters
Monitoring	None

An External Open trip occurs if the main contactor is detected as having been opened while the system is in run mode.

External open protection activates in approximately 1sec.

7.4.5 Coil Voltage Detection

Table 15: Protection Module – Coil Voltage Detection Trip Characteristics

Parameter	***Action***
Power Cycle	-
Reset	Automatic
Trip Actions	Open Circuit Breaker Prevent Main Contactor from closing
Active Period	Always
Logging	Only logged if it results in the Protection Module stopping a running outlet
Parameters	No parameters
Monitoring	Coil voltage status bit

The coil voltage is internally detected by sensing the voltage across terminals 12 & 13 (COIL-SUPPLY-1 & COIL-SUPPLY-2). This additional functionality is provided so in the event of the Contactor coil voltage being lost while the outlet is running a nuisance Main Contactor Failure trip does not occur, as the changing of state for the Main Contactor can be explained by the loss of coil voltage.

7.4.6 MCF Latch

AS/NZS 4871.1 Clause 2.6.3.6 requires contactor related trips to be reset only by an authorised person. To this end it is deemed that physical access inside the switchgear enclosure would be required to perform the relevant checks, and as such the Main Contactor Failure reset is a push-button on the Protection Module. All trips bits that feed into the Main Contactor Failure Flag are individually logged in the Protection Module for event analysis in the instance of a Circuit Breaker Trip.

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8 CURRENT RELATED PROTECTION FUNCTIONS

Three current transformers within the Cassette are used to measure the three line currents. The measured currents are used to implement the following protection functions:

- Inverse time protection - Over-Current or Motor Overload
- Short circuit
- Under current
- Phase current balance

The 'Full Load Current Range' setting determines the base current for all of the phase current related functions: the measured currents are normalized based on the selected value. The range is selectable from 5.125A to 640A.

8.1 Inverse Time Protection

The 'Over Current Curve' setting is used to select one of three Inverse Time-Current characteristics:

- Very Inverse Over Current
- Extremely Inverse Over Current
- Motor Overload

NOTE

When the Motor Overload parameter is set, the Short Circuit functionality is also modified to better suit motor starting transients. See the Short Circuit section (Section 8.2) for further information.

The Over Current Time Multiplier setting (TMS) scales the basic trip time for the basic over current characteristics to the desired response time. Values are provided from 0.05 to 30; refer to Appendix A for the full list of values. For cross reference, the nominal trip times are listed for each TMS value, for each of the curve options at 10x FLC.

8.1.1 Over Current

Table 16: Protection Module – Over Current Trip Characteristics

Parameter	***Action***
Power Cycle	-
Reset	Requires a general reset (and all three measured phase currents must be below the 100%).
Trip Actions	Open Main Contactor Prevent Main Contactor from closing Block restart if the thermal accumulator is not below the selected start block level.
Active Period	When Over Current curve is set to Very Inverse or Extremely Inverse.
Logging	Always
Parameters	Time Multiplier Full Load Current
Monitoring	Phase currents displayed as a percentage of selected full load current Thermal Accumulator (TAC)

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The three phase currents are compared and the highest current is used to determine the trip time. If the current exceeds the selected full load current, an overcurrent trip accumulator (TAC) increases at a rate determined by the above function. If the over-current condition persists so that the trip accumulator reaches 100% then a trip occurs. If viewed during start up the trip accumulator can help determine if the over-current settings are correct.

The Overcurrent curves provided are as follows:

1. **Very Inverse** as per IEC 60255-151 B Curve. The trip time and reset time in seconds for current I follows the characteristic defined by :

$$t(I) = TMS \cdot \left(\frac{13.5}{I-1}\right)$$

$$t_R(I) = TMS \cdot \left(\frac{1.69}{1-I}\right)$$

2. **Extremely Inverse** as per IEC 60255-151 C Curve. The trip time and reset time in seconds for current I follows the characteristic defined by :

$$t(I) = TMS \cdot \left(\frac{80}{I^2-1}\right)$$

$$t_R(I) = TMS \cdot \left(\frac{1.28}{1-I^2}\right)$$

Where:

t(I) = the idealised trip time,

I = the input current ratio relative to the full load current set point – ie per unit current,

TMS = the Over Current Time Multiplier Setting,

tR (I) = the idealised reset time.

NOTE

1. The per unit current is clipped to a maximum of 1250%. Therefore the trip time for input currents above this level will not decrease any further i.e. the trip characteristic 'flat lines' beyond 1250% of the selected full load current.
2. Independent of the selected curve and TMS setting, the minimum trip times for the Over Current functions are nominally 100ms.
3. The trip times calculated from the above formulae are idealised. The trip calculations are executed every 20ms, so there is an additional delay and uncertainty of 25ms +/-15ms.

See Overcurrent Curves, drawing IPXB014 in Appendix B.

When the Protection Module is not in the 'running' state, if the thermal accumulator is not below the selected start block level, a start block (trip) will occur. This will automatically clear once the thermal accumulator drops to, or is below the selected level. Note however that generally this will happen quickly when the inverse overcurrent modes are selected.

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8.1.2 Motor Overload

Table 17: Protection Module – Motor Overload Trip Characteristics

Parameter	***Action***
Power Cycle	Trip Status maintained
Reset	Requires a general reset (and all three measured phase currents must be below the 100%).
Trip Actions	Open Main Contactor Prevent Main Contactor from closing Block restart if the thermal accumulator is not below the selected start block level.
Active Period	When Over Current curve is set to Motor Overload.
Logging	Always
Parameters	Time Multiplier Full Load Current Cooling Multiplier
Monitoring	Phase currents displayed as a percentage of selected full load current TAC.

This protection scheme uses a simple first order thermal model of the motor to determine the tripping characteristic. It is fundamentally different to the Over Current protection outlined above in that it all current levels contribute to the model heating, and the effects of that heating persist in the model, where as in the Over Currents functions, the trip accumulator resets relatively quickly if the current falls below the selected full load current level.

The three measured phase currents are squared and added together to provide the heating input into the thermal model. The cooling is assumed to be proportional to the model's 'temperature' at any given time. The Thermal Accumulator (TAC) is the model's 'temperature' where 0% represents the motor being cold, and 100% means the motor has reached its maximum temperature (and is therefore tripped).

The trip time is dependant not only on the present current level, but also the prior current history. Since motor currents typically vary widely during starting and running, the actual trip time is also variable. To facilitate co-ordination of the protection with motor capabilities (and upstream protection), the trip time in seconds for a simple (theoretical) scenario of a fixed overload current of I is given by:

$$t(I) = TMS \cdot 72.9 \cdot ln\left(\frac{I^2 - {I_p}^2}{I^2 - 1.05^2}\right)$$

Where:

t(I) = the idealised trip time,

I = the input current ratio relative to the full load current set point – ie per unit current,

TMS = the Over Current Time Multiplier Setting,

Ip = the load current that was flowing (long enough to reach thermal stability) prior to the overload occurrence.

ln = the natural logarithm.

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NOTE

1. The per unit current is clipped to a maximum of 1250%. Therefore the trip time for input currents above this level will not decrease any further: ie, the trip characteristic 'flat lines' beyond 1250% of the selected full load current.
2. Independent of the selected TMS setting, the minimum trip times for the Overload function is nominally 100 ms.
3. The trip times calculated from the above formulae are idealized. The trip calculations are executed every 20 ms, so there is an additional delay and uncertainty of 25 ms +/-15 ms.
4. The above characteristic is equivalent to IEC 60255-8 (equation below) with the substitution of $\boldsymbol{\tau}$ =TMS • 72.9. This scaling aligns the trip time at 10 PU current with that of the Extremely Inverse curve above (eg 808ms with a TMS of 1.0).

$$t = \tau \cdot \ln\left(\frac{I^2 - {I_p}^2}{I^2 - (k \cdot I_B)^2}\right)$$

Where in the Protection Module:

k = 1.05, called the 'Service Factor'

IB = 1.

The base thermal model provides a thermal time constant of 72.9 seconds. The TMS setting scales the basic thermal time constant, allowing a maximum time constant of over 36 minutes (TMS = 30).

See Motor Overload Curves drawing IPXB013 in Appendix B.

The TAC provides information about how much thermal capacity is left, and therefore how long it will take to trip from given starting point and overload current. If the motor current I is constant (and below 1.05PU), the TAC will eventually settle to a value as follows:

$$TAC = \left(\frac{I}{1.05}\right)^2 \cdot 100\ \%$$

For example, if the long term average load current was 0.7PU, the TAC would settle at 44%.

The relative trip time for a constant current as a function of the initial value of the TAC is given by:

$$t(TAC) = (\ 100\% - TAC\ ) \cdot Cold\ Trip\ Time$$

Continuing the example above, with the TAC starting at 44%, the trip time would be 56% of the cold trip time (for the same current), that is, if the long term average current (Ip) prior to an overload was 0.7PU, the trip time for an over an overload from that starting point would be 56 % of the trip time for the same overload current starting from cold. Drawing IPXB013 also shows the overload curve for various values of Ip.

The motor manufacturer's data should be consulted to select the time multiplier appropriate for the motor being protected. Typically, the capacity of a cold motor is given at six times its rated current. The characteristic equation above can be used to select the TMS to match the motors overload capacity.

While the main contactor is closed, the cooling output from the thermal model is calculated to achieve the necessary behaviour to match the characteristic above.

The Over Load Cooling Multiplier modifies the cooling output of the thermal model when the motor is

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stopped. This can be used to account for reduced cooling capacity of the motor when it is not running. A Cooling multiplier of 1 means the cooling is independent of whether the motor is running or not – eg a water-cooled motor. A setting of 2.5 may be appropriate for a fan-cooled motor, however for the best protection consult the motor manufacturer. Values are provided from 1.0 to 5.0.

The thermal model continues to simulate the motor's thermal behaviour even if the power is removed from the relay. When power is restored the thermal memory would be at the same level had there been no loss of power.

The "Thermal Accumulator" shows the state of the thermal model: 0% = Cold, 100% = Trip. When a trip occurs it cannot be reset until the current is below the pick-up level.

When the Protection Module is not in the 'running' state, if the thermal accumulator is not below the selected start block level, a 'start block' (trip) will occur. This will automatically clear once the thermal accumulator drops to, or is below the selected level. This functionality is used to ensure adequate thermal capacity is available before another start is allowed. If necessary it will force sufficient cooling time to allow the restoration of sufficient thermal reserve. If for example the application required capability to permit a locked rotor start lasting up to 60% of the allowable 'cold' locked rotor start time (before tripping on Motor Overload), the 'Start Block Level' parameter would be set to 40%.

In order to allow an emergency restart on a hot motor, a reset of the thermal memory is possible – but the risk of permanent motor damage must be carefully considered before taking this step.

CAUTION!

Incorrect motor protection setup, or **thermal memory resets may cause or lead to motor failure or permanent motor damage**.

8.2 Short Circuit

Table 18: Protection Module – Short Circuit Trip Characteristics

Parameter	***Action***
Power Cycle	Trip Status maintained
Reset	Specific short circuit reset
Trip Actions	Open selected output – circuit breaker or main contactor Prevent Main Contactor from closing
Active Period	Always
Logging	When a fault occurs
Parameters	Short Circuit Output Relay Short Circuit Trip Level Short Circuit Trip Time
Monitoring	Phase currents displayed as a percentage of selected full load current.

The short circuit function has a definite time characteristic. If the current exceeds the selected level for the pre-set time then a trip occurs.

The short circuit trip level is adjustable from 1.5 to 12.5 times (full load current) in 0.25 increments. Note however that there is also an upper limit in the current measuring system of 6kA (RMS). This limit will effectively over ride selections where the combination of the selected full load current and the selected

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short circuit level exceeds 6kA. For example, if 640A is selected, the short circuit will trip at 9.4PU (940%) even if the short circuit level is set to 9.5x or above. The per unit current at which the 6kA limit takes effect is listed as 'SC max' along with the full range current values in Appendix A.

The trip time is selectable from 40 to 200ms.

If the Over Current function is set to Motor Overload, the short circuit functionality is modified as follows:

1. The primary 'instantaneous' short circuit trip level is double the selected value: therefore, so it covers a range of 3.0 to 25 times full load current.
2. A second 'time delayed' short circuit element becomes active. This element operates at the selected Short Circuit Trip Level, but the trip time is the selected (primary) trip time plus 60ms.

There is a separate 'SC-LT' trip bit (LT for 'long time') & event log to differentiate each of the short circuit elements.

This modified functionality allows the short circuit protection to be set just above the locked rotor current level without risking spurious trips due to initial transient offsets (which can effectively double the initial inrush peak current).

The Short Circuit Output Relay setting is used to control which trip action a short circuit trip: the trip can be directed to either the CBR (preferred) or the MCR.

WARNING!

The circuit interrupting device tripped by the selected output relay for the Short Circuit function **MUST be rated to interrupt the full prospective system short circuit current**.

If the Short Circuit Output Relay setting is set to 'CBR', when a short circuit trip occurs, the circuit breaker is opened and the main contactor left closed for one second to allow the circuit breaker time to clear the fault. Any other trips or control actions to open the contactor during this time – except for earth leakage, will be blocked.

8.3 Current Balance

Table 19: Protection Module – Current Balance Trip Characteristics

Parameter	***Action***
Power Cycle	Trip Status maintained
Reset	General reset
Trip Actions	Open Main Contactor Prevent Main Contactor from closing
Active Period	Always
Logging	Always
Parameters	Trip Level
Monitoring	Phase currents displayed in Amps.

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The current balance measurement is available and is calculated as:

$$i_{bal} = \frac{MAX\ \Delta\ i \times 100\%}{i_{av}}$$

Where:

iav = the average of the 3 phase currents

MAX ∆ i = the maximum deviation of a phase current from the average.

The trip level is selectable at 5%, 10%, 20%, and 50% and off.

The phase current balance protection is inhibited until the average current exceeds both 20% of the selected full load current and the selected balance trip level.

If the trip level is exceeded, a timer is triggered. If the imbalance remains above the set level for more than two seconds the relay trips.

8.4 Under Current

Table 20: Protection Module – Under Current Trip Characteristics

Parameter	***Action***
Power Cycle	-
Reset	Automatic
Trip Actions	Open Main Contactor Prevent Main Contactor from closing
Active Period	When outlet is running
Logging	When a fault occurs
Parameters	Trip Level
Monitoring	Phase currents displayed in Amps.

Under current protection monitors all three phase currents. If any phase drop below the selected threshold, the trip timer start counting. The under current protection will trip after any phase current is below the threshold for 4 second.

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9 OTHER PROTECTION FUNCTIONS

9.1 Under Voltage

Table 21: Protection Module – Under Voltage Trip Characteristics

Parameter	***Action***
Power Cycle	-
Reset	Automatic
Active Period	When outlet is running
Logging	Only if outlet is running
Parameters	Trip Level
Monitoring	Phase voltage displayed in Volts.

Under Voltage protection is enabled as soon as the main contactor is closed (indicated by closing the MCI input). If any of the phase voltages drop below the selected trip setting of the nominal line voltage for 800ms then the outlet is stopped.

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10 SERVICE, MAINTENANCE & DISPOSAL

10.1 Equipment Service

A number of external system based checks should be completed on a regular basis. These 'routine inspections' must be carried out by suitably trained people with knowledge of the OCS and the systems into which it is fitted. Routine inspections may take the form of either visual-only checks, or visual and 'hands-on' checks.

10.1.1 Visual Only Inspections

A basic visual inspection focuses on looking at the installation for signs of physical damage, water or dust ingress and the condition of cables and labels. This type of inspection may involve opening cabinets to gain access to the OCS and other equipment. This level of inspection may also include cleaning display windows that have become obscured by dirt.

Observations would typically be:

- Check that equipment enclosures, cable trays, conduits, etc. are in good order with no physical damage.
- Check that connected cables are free from cuts, abrasions and obvious signs of damage. Cable restraints are in good order and correctly fitted.
- Check that labels on equipment and cables are present and in good condition (especially certification labels).
- Check that no modifications have been carried out to installed equipment.

10.1.2 Hands-On (Detailed) Inspections

A more detailed inspection would include all of the elements of a visual inspection, plus some checks that cover the integrity of connections, fixtures and fittings.

In addition to basic visual observations, more detailed integrity checks would involve:

- Verify that equipment housings and other mechanical fixtures are secured in place. This includes terminal box lids, tightness of cable glands, integrity of mountings, security of equipment fixing to walls/DIN rails etc.
- Verify all electrical connections are secure with no loose screw terminals or DIN rail terminals not fitted to rails etc.
- If required, apply electrical contact grease to cassette contacts to reduce wear.

10.1.3 Offsite Overhaul

In line with AS/NZS 2290:2014, for continued reliable and safe performance, Ampcontrol recommends that each Cassette is overhauled to AS/NZS 3800 and Ampcontrol's work instructions at intervals not exceeding that as recommended by the standard.

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10.2 Equipment Maintenance

WARNING!

The OCS has no user-serviceable parts.

All repairs must be carried out by Ampcontrol only.

If a fault develops, return the Cassette to Ampcontrol for repair. It is essential that **no attempt be made to repair the Cassette** as any attempt to dismantle or repair the Cassette can **seriously compromise the safety of the unit and voids product warranty**.

It is recommended that the electrical protection system incorporating the OCS be subject to regular functional tests at intervals determined by risk assessment or FMEA. These intervals typically coincide with periodic maintenance checks and will cover (but not limited to) tests such as:

- Earth Leakage injection tests
- Earth Continuity tests
- Earth Fault Lockout tests
- Overcurrent injection tests

CAUTION!

When conducting **insulation tests** on the outgoing power circuits, ensure that the **Cable Connection Module (CCM) in the Protection Module is disconnected**. Failure to do so may **damage the Protection Module**.

10.3 Disposal

ENVIRO

The electronic equipment discussed in this manual **must not be treated as general waste**. By ensuring that this product is disposed of correctly you will be helping to prevent potentially negative consequences for the environment which could otherwise be caused by incorrect waste handling of this product.

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11 SPECIFICATIONS

11.1 Cassette Specifications

General	
Nominal System Voltage	Up to 3.3kV
Continuous Current Rating	Up to 500A (Thermal)
Protection Relay	Outlet Cassette Protection Module
Plug-In Capability	Yes

11.2 Protection Module Specifications

I.S. Parameters		
Combined Phase and Pilot	***RDX Port***	***RTX***
Uo: 28.0V	Uo: 17.3V	Ui: 28.0V
Io: 322mA	Io: 756mA	Ci: 18.8nF
Po: 2.25W	Po: 3.09W	Li: nil
Co: 3.72µF	Co: 9.05µF	
Ci: 18.8nF	Lo: 816µH	
Lo: 4.5mH	L/R: 134µH/Ohm	

General	
Temperature Range	0°C < Ta < 60°C
Auxiliary Supply Voltage	24 VDC ± 20%, 30 W
Sys. Phase-Phase Voltage	1100V ± 20%, 3.3kV ± 20%
Contact Ratings	110VAC 20A, 1000VA, Power Factor 0.4

AS/NZS2081:2011 Protection Functions	
Earth Leakage	
Trip Settings +/-10%	100mA, 150mA, 200mA, 250mA, 300mA, 350mA, 400mA, 450mA, 500mA
Trip Time +0% -20%	Inst., 50ms, 75ms, 100ms, 150ms, 200ms, 250ms, 300ms, 350ms, 400ms, 450ms, 500ms
CT Failure	500ms

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AS/NZS2081:2011 Protection Functions	
Earth Continuity	
Series Trip +/-3Ω	10Ω, 15Ω, 20Ω, 25Ω, 30Ω, 35Ω, 40Ω, 45Ω
Shunt Trip	1kΩ
Trip Time	100ms, 150ms, 200ms, 250ms, 300ms, 350ms, 400ms, 450ms, 500ms
Earth Fault Lockout	
IS Test	1MΩ (all phases in parallel)
HV Insulation Test	OFF, 2.5MΩ, 5MΩ, 10MΩ, 20MΩ, 50MΩ
Contactor Protection	
Loss of Coil Voltage	< 100ms
Loss of Vacuum	< 1s
Frozen Contactor	< 100ms
Loss of Contactor Control	< 1s
Back EMF Time	2s, 5s, 10s, 15s, 20s
Loss of Control	< 1s
LOV Level	25VAC, 50VAC

Current Related Functions	
Over Current Protection	
Curves	Very Inverse as per IEC 60255-151 B Curve, or Extremely Inverse as per IEC 60255-151 C Curve
Current Range	See Protection Module Full Load Current Selection Table (Appendix A)
Time Multiplier	0.05-30 (See Protection Module TMS Table)
Motor Thermal Overload	
Full Load Current	See Protection Module Full Load Current Selection Table (Appendix A)
Time Multiplier	0.05-30 (See Protection Module TMS Table)
Cooling Multiplier	1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0
Start Block Level	20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%

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Current Related Functions	
Short Circuit Protection	
Trip Settings	1.5x to 12.5x in 0.25x increments in OC mode, 3.0x to 25x when in MOL mode with addition slower trip element at 1.5x to 12.5x (Multiples of Full Load Current) Trip occurs at the level determined by selected Full Load Current x SC Level or 6 kA, whichever is lesser.
Trip Time	40ms, 60ms, 80ms, 100ms, 120ms, 140ms,160ms, 180ms, 200ms (All times are +/- 15ms)
Current Monitoring	
Under Current	0% (Disabled), 30%,35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%
Current Balance	5%, 10%, 20%, 50%, OFF

Other Protection Functions	
Under Voltage Protection	
Trip Settings	Off, 40%, 50%, 60%, 70%, 75%, 80%, 85%, 90%, 95%
Trip Time	850ms

12 EQUIPMENT LIST

Part Number	***Description***
174431	OCS Cassette c/w Protection Module
159325	Outlet Cassette Protection Module (Spare Part)
160292	Outlet Cassette Remote Termination Unit (RTX)
101649	Earth Leakage Toroid – EL500/60/100T 500mA 60mmID
101650	Earth Leakage Toroid – EL500/85/100T 500mA 85mmID
101654	Earth Leakage Toroid – EL500/112/100T 50mA 112mmID

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APPENDIX A: PROTECTION MODULE LOAD CURRENT TABLES

A1: Protection Module Full Load Current Table

Protection Module Full Load Current Selection Table – Amps (1000:1 CT), and Max effective SC Level

Value	Amps	Value	Amps	Value	Amps	Value	Amps	Value	Amps	Value	Amps	SC max	Value	Amps	SC max
0	5.125	32	10.25	64	20.5	96	41	128	82	160	164	25.0x	192	328	18.3x
1	5.250	33	10.50	65	21.0	97	42	129	84	161	168	25.0x	193	336	17.9x
2	5.375	34	10.75	66	21.5	98	43	130	86	162	172	25.0x	194	344	17.4x
3	5.500	35	11.00	67	22.0	99	44	131	88	163	176	25.0x	195	352	17.0x
4	5.625	36	11.25	68	22.5	100	45	132	90	164	180	25.0x	196	360	16.7x
5	5.750	37	11.50	69	23.0	101	46	133	92	165	184	25.0x	197	368	16.3x
6	5.875	38	11.75	70	23.5	102	47	134	94	166	188	25.0x	198	376	16.0x
7	6.000	39	12.00	71	24.0	103	48	135	96	167	192	25.0x	199	384	15.6x
8	6.125	40	12.25	72	24.5	104	49	136	98	168	196	25.0x	200	392	15.3x
9	6.250	41	12.50	73	25.0	105	50	137	100	169	200	25.0x	201	400	15.0x
10	6.375	42	12.75	74	25.5	106	51	138	102	170	204	25.0x	202	408	14.7x
11	6.500	43	13.00	75	26.0	107	52	139	104	171	208	25.0x	203	416	14.4x
12	6.625	44	13.25	76	26.5	108	53	140	106	172	212	25.0x	204	424	14.2x
13	6.750	45	13.50	77	27.0	109	54	141	108	173	216	25.0x	205	432	13.9x
14	6.875	46	13.75	78	27.5	110	55	142	110	174	220	25.0x	206	440	13.6x
15	7.000	47	14.00	79	28.0	111	56	143	112	175	224	25.0x	207	448	13.4x
16	7.125	48	14.25	80	28.5	112	57	144	114	176	228	25.0x	208	456	13.2x
17	7.250	49	14.50	81	29.0	113	58	145	116	177	232	25.0x	209	464	12.9x
18	7.375	50	14.75	82	29.5	114	59	146	118	178	236	25.0x	210	472	12.7x
19	7.500	51	15.00	83	30.0	115	60	147	120	179	240	25.0x	211	480	12.5x
20	7.625	52	15.25	84	30.5	116	61	148	122	180	244	24.6x	212	488	12.3x
21	7.750	53	15.50	85	31.0	117	62	149	124	181	248	24.2x	213	496	12.1x
22	7.875	54	15.75	86	31.5	118	63	150	126	182	252	23.8x	214	504	11.9x
23	8.000	55	16.00	87	32.0	119	64	151	128	183	256	23.4x	215	512	11.7x
24	8.250	56	16.50	88	33.0	120	66	152	132	184	264	22.7x	216	528	11.4x

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Protection Module Full Load Current Selection Table – Amps (1000:1 CT), and Max effective SC Level

Value	Amps	Value	Amps	Value	Amps	Value	Amps	Value	Amps	Value	Amps	SC max	Value	Amps	SC max
25	8.500	57	17.00	89	34.0	121	68	153	136	185	272	22.1x	217	544	11.0x
26	8.750	58	17.50	90	35.0	122	70	154	140	186	280	21.4x	218	560	10.7x
27	9.000	59	18.00	91	36.0	123	72	155	144	187	288	20.8x	219	576	10.4x
28	9.250	60	18.50	92	37.0	124	74	156	148	188	296	20.3x	220	592	10.1x
29	9.500	61	19.00	93	38.0	125	76	157	152	189	304	19.7x	221	608	9.9x
30	9.750	62	19.50	94	39.0	126	78	158	156	190	312	19.2x	222	624	9.6x
31	10.00	63	20.00	95	40.0	127	80	159	160	191	320	18.8x	223	640	9.4x

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A2: Protection Module TMS Table

Protection Module Over Current Time Multiplier Settings (TMS) including nominal trip time in seconds at 10 PU Current

Value	TMS	10 x trip time	
		Ext Inv. & MOL	Very Inv.
0	0.050	0.040	0.075
1	0.055	0.044	0.083
2	0.060	0.048	0.090
3	0.065	0.053	0.098
4	0.070	0.057	0.105
5	0.075	0.061	0.113
6	0.080	0.065	0.120
7	0.085	0.069	0.128
8	0.090	0.073	0.135
9	0.10	0.081	0.150
10	0.11	0.089	0.165
11	0.12	0.097	0.180
12	0.13	0.105	0.195
13	0.14	0.113	0.210
14	0.15	0.121	0.225
15	0.16	0.129	0.240
16	0.17	0.137	0.255
17	0.18	0.145	0.270
18	0.19	0.154	0.285
19	0.20	0.162	0.300
20	0.22	0.178	0.330
21	0.24	0.194	0.360
22	0.26	0.210	0.390
23	0.28	0.226	0.420
24	0.30	0.242	0.450

Value	TMS	10 x trip time	
		Ext Inv. & MOL	Very Inv.
30	0.50	0.404	0.750
31	0.55	0.444	0.825
32	0.60	0.485	0.900
33	0.65	0.525	0.975
34	0.70	0.566	1.050
35	0.75	0.606	1.125
36	0.80	0.646	1.200
37	0.85	0.687	1.275
38	0.90	0.727	1.350
39	1.0	0.808	1.50
40	1.1	0.889	1.65
41	1.2	0.970	1.80
42	1.3	1.05	1.95
43	1.4	1.13	2.10
44	1.5	1.21	2.25
45	1.6	1.29	2.40
46	1.7	1.37	2.55
47	1.8	1.45	2.70
48	1.9	1.54	2.85
49	2.0	1.62	3.00
50	2.2	1.78	3.30
51	2.4	1.94	3.60
52	2.6	2.10	3.90
53	2.8	2.26	4.20
54	3.0	2.42	4.50

Value	TMS	10 x trip time	
		Ext Inv. & MOL	Very Inv.
60	5.0	4.04	7.50
61	5.5	4.44	8.25
62	6.0	4.85	9.00
63	6.5	5.25	9.75
64	7.0	5.66	10.50
65	7.5	6.06	11.25
66	8.0	6.46	12.00
67	8.5	6.87	12.75
68	9.0	7.27	13.50
69	10.0	8.08	15.0
70	11.0	8.89	16.5
71	12.0	9.70	18.0
72	13.0	10.51	19.5
73	14.0	11.31	21.0
74	15.0	12.12	22.5
75	16.0	12.93	24.0
76	17.0	13.74	25.5
77	18.0	14.55	27.0
78	19.0	15.35	28.5
79	20.0	16.16	30.0
80	22.0	17.78	33.0
81	24.0	19.39	36.0
82	26.0	21.01	39.0
83	28.0	22.63	42.0
84	30.0	24.24	45.0

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Protection Module Over Current Time Multiplier Settings (TMS) including nominal trip time in seconds at 10 PU Current

Value	TMS	10 x trip time	
		Ext Inv. & MOL	Very Inv.
25	0.32	0.259	0.480
26	0.35	0.283	0.525
27	0.38	0.307	0.570
28	0.42	0.339	0.630
29	0.46	0.372	0.690

Value	TMS	10 x trip time	
		Ext Inv. & MOL	Very Inv.
55	3.2	2.59	4.80
56	3.5	2.83	5.25
57	3.8	3.07	5.70
58	4.2	3.39	6.30
59	4.6	3.72	6.90

Value	TMS	10 x trip time	
		Ext Inv. & MOL	Very Inv.

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APPENDIX B: DRAWINGS

The drawings in this appendix are as per the below table.

Drawing Number	Drawing Title	Page Number
IPXE002	Typical Connection Diagram	55
IPXE014	I.S. System Diagram	56
IPXA003	Protection Module Mechanical Details	57
IPXB014	Overcurrent and Short Circuit Curves	58
IPXB013	Motor Overload and Short Circuit Curves	59

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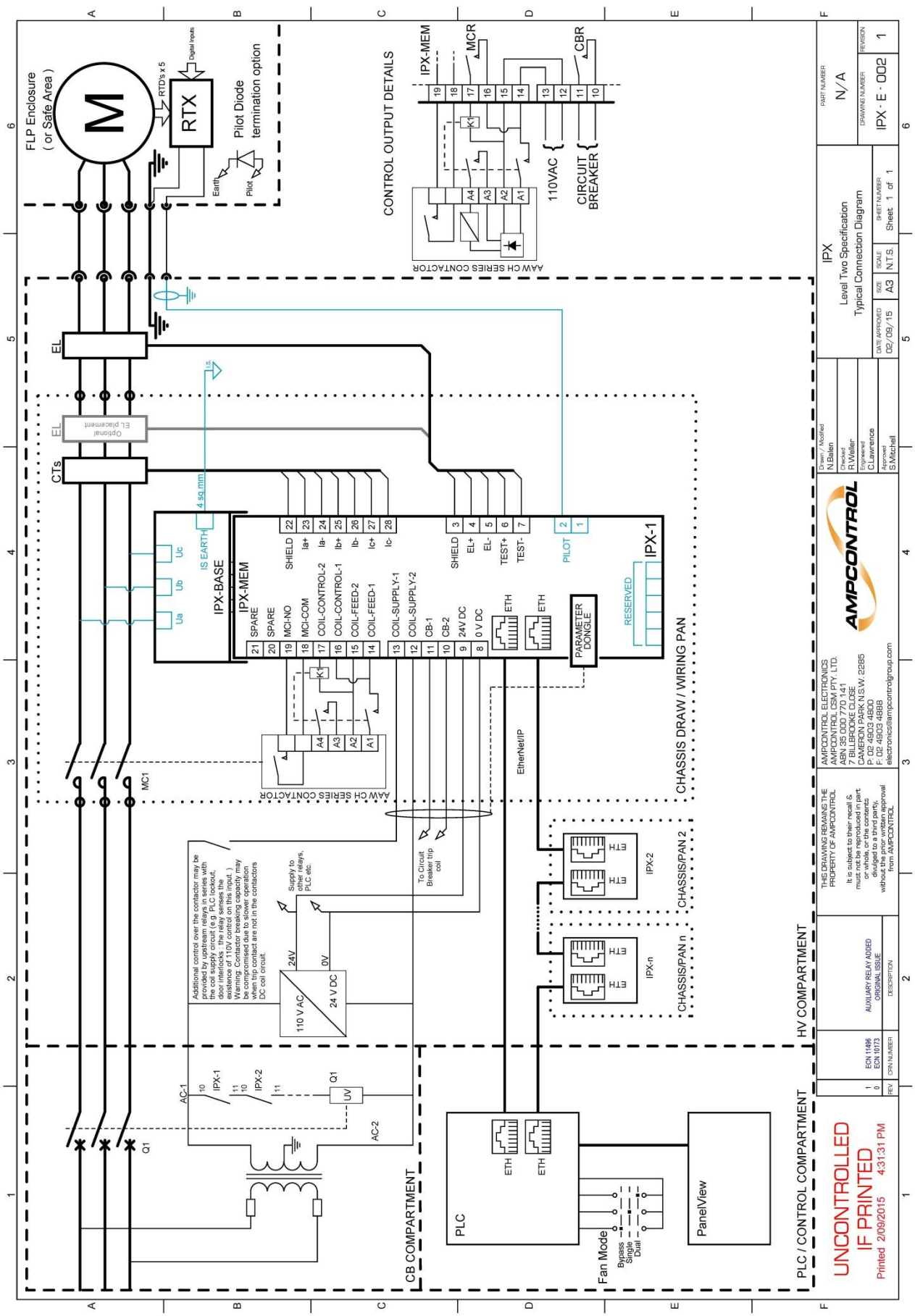

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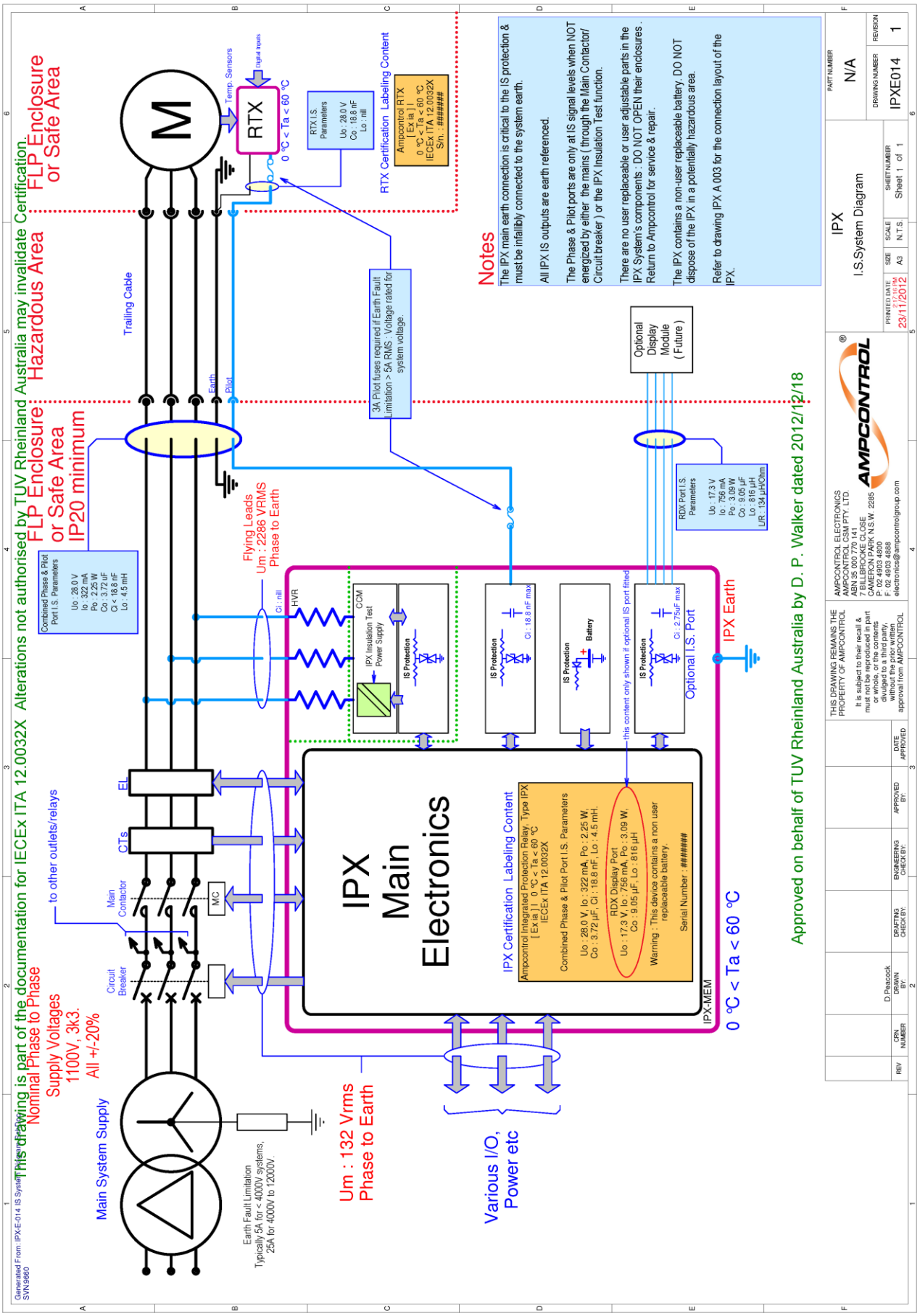
FLP Enclosure or Safe Area
Hazardous Area
FLP Enclosure or Safe Area IP20 minimum
Alterations not authorised by TUV Rheinland Australia may invalidate Certification.
This drawing is part of the documentation for IECEx ITA 12.0032X
Nominal Phase to Phase Supply Voltages 1100V, 3k3. All +/-20%
Main System Supply
to other outlets/relays
Main Contactor
Circuit Breaker
MC
EL
CTs
Trailing Cable
Earth
Pilot
Temp. Sensors
Digital Inputs
RTX
0 °C < Ta < 60 °C
RTX I.S. Parameters
Uo : 28.0 V
Co : 18.8 nF
Lo : nil
RTX Certification Labeling Content
Ampcontrol RTX
[Ex ia] I
0 °C < Ta < 60 °C
IECEx ITA 12.0032X
S/n : #######
3A Pilot fuses required if Earth Fault Limitation > 5A RMS : Voltage rated for system voltage.
Combined Phase & Pilot Port I.S. Parameters
Uo : 28.0 V
Io : 322 mA
Po : 2.25 W
Co : 3.72 uF
Ci < 18.8 nF
Lo : 4.5 mH
Flying Leads
Um : 2286 VRMS
Phase to Earth
Ci : nil
HVR
CCM
IPX Insulation Test Power Supply
IS Protection
Ci : 18.8 nF max
Battery
Ci : 2.75uF max
Optional I.S. Port
this content only shown if optional IS port fitted
IPX Earth
IPX Main Electronics
IPX Certification Labeling Content
Ampcontrol Integrated Protection Relay, Type IPX
[Ex ia] I 0 °C < Ta < 60 °C
IECEx ITA 12.0032X
Combined Phase & Pilot Port I.S. Parameters
Uo : 28.0 V, Io : 322 mA, Po : 2.25 W,
Co : 3.72 µF, Ci : 18.8 nF, Lo : 4.5 mH.
RDX Display Port
Uo : 17.3 V, Io : 756 mA, Po : 3.09 W,
Co : 9.05 µF, Lo : 816 µH
Warning : This device contains a non user replaceable battery.
Serial Number : #######
IPX-MEM
0 °C < Ta < 60 °C
Optional Display Module (Future)
RDX Port I.S. Parameters
Uo : 17.3 V
Io : 756 mA
Po : 3.09 W
Co : 9.05 µF
Lo : 816 µH
L/R : 134 µH/Ohm
Notes
The IPX main earth connection is critical to the IS protection & must be infallibly connected to the system earth.
All IPX IS outputs are earth referenced.
The Phase & Pilot ports are only at IS signal levels when NOT energized by either the mains (through the Main Contactor/ Circuit breaker) or the IPX Insulation Test function.
There are no user replaceable or user adjustable parts in the IPX System's components : DO NOT OPEN their enclosures. Return to Ampcontrol for service & repair.
The IPX contains a non-user replaceable battery. DO NOT dispose of the IPX in a potentially hazardous area.
Refer to drawing IPX A 003 for the connection layout of the IPX.
Approved on behalf of TUV Rheinland Australia by D. P. Walker dated 2012/12/18
Um : 132 Vrms Phase to Earth
Various I/O, Power etc
Earth Fault Limitation
Typically 5A for < 4000V systems, 25A for 4000v to 12000v.
IPX I.S.System Diagram
PART NUMBER N/A
DRAWING NUMBER IPXE014
REVISION 1
SHEET NUMBER Sheet 1 of 1
SCALE N.T.S.
SIZE A3
PRINTED DATE 23/11/2012 17:16 PM
AMPCONTROL ELECTRONICS
AMPCONTROL GSM PTY. LTD.
ABN 35 000 770 141
7 BILLBROOKE CLOSE
CAMERON PARK N.S.W. 2285
P : 02 4903 4800
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electronics@ampcontrolgroup.com
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REV
ORN NUMBER
DRAWN BY: D.Peacock
DRAFTING CHECK BY:
ENGINEERING CHECK BY:
APPROVED BY:
DATE APPROVED
Generated From: IPXE-014 IS System
SVN:9660

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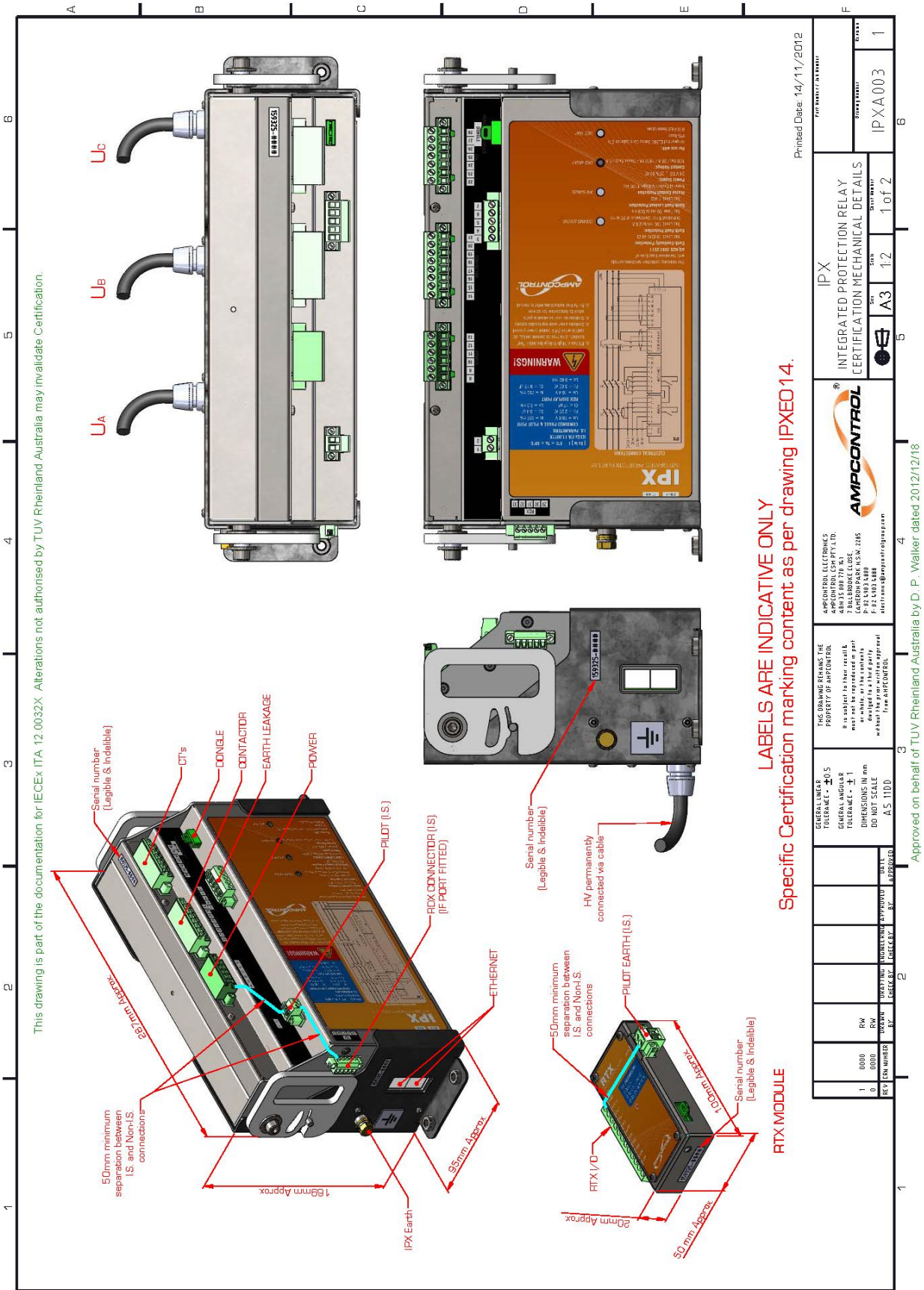

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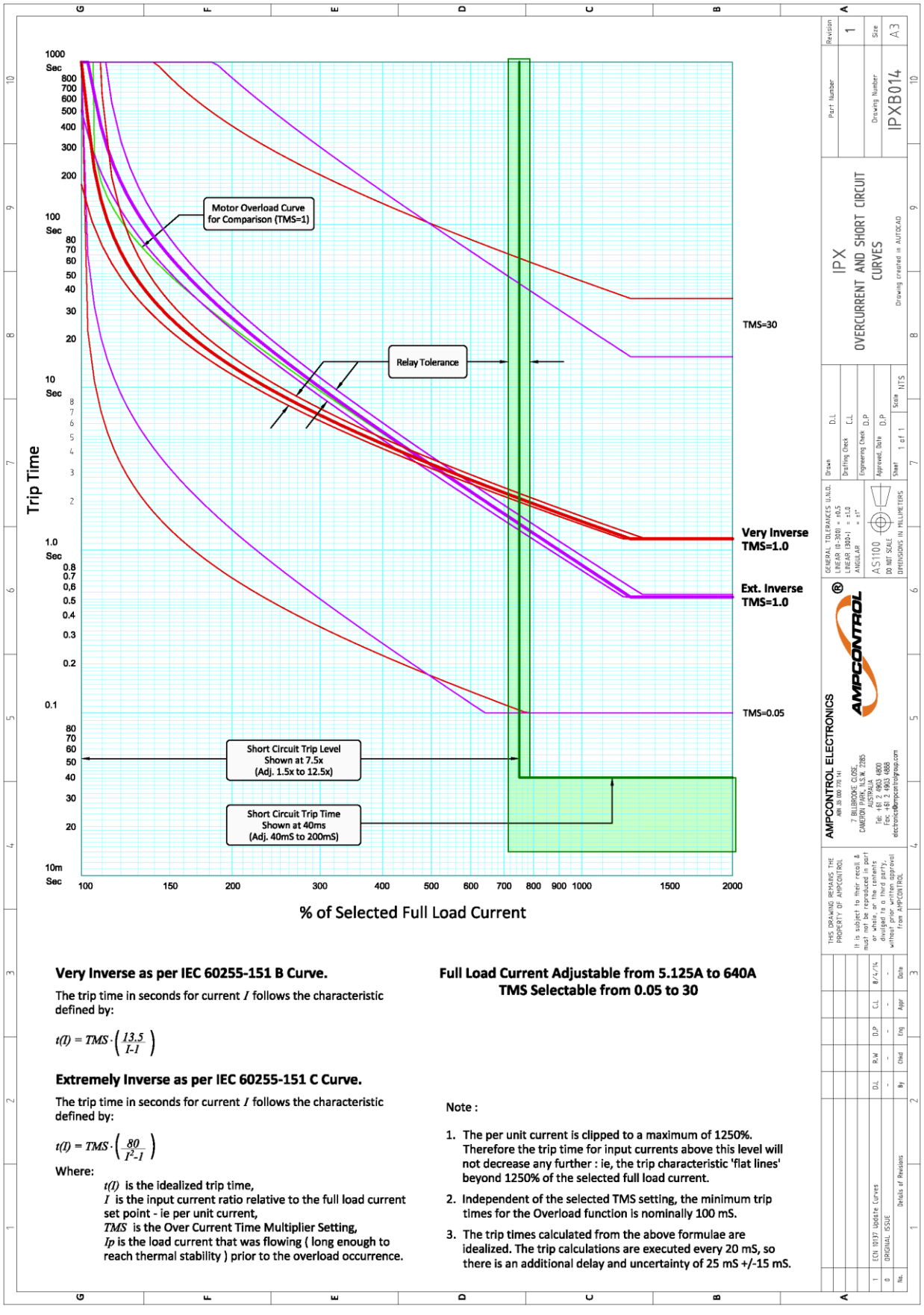

Very Inverse as per IEC 60255-151 B Curve.

The trip time in seconds for current I follows the characteristic defined by:

$$t(I) = TMS \cdot \left(\frac{13.5}{I-1} \right)$$

Extremely Inverse as per IEC 60255-151 C Curve.

The trip time in seconds for current I follows the characteristic defined by:

$$t(I) = TMS \cdot \left(\frac{80}{I^2-1} \right)$$

Where:

$t(I)$ is the idealized trip time,
I is the input current ratio relative to the full load current set point - ie per unit current,
TMS is the Over Current Time Multiplier Setting,
Ip is the load current that was flowing (long enough to reach thermal stability) prior to the overload occurrence.

Full Load Current Adjustable from 5.125A to 640A
TMS Selectable from 0.05 to 30

Note :

1. The per unit current is clipped to a maximum of 1250%. Therefore the trip time for input currents above this level will not decrease any further : ie, the trip characteristic 'flat lines' beyond 1250% of the selected full load current.
2. Independent of the selected TMS setting, the minimum trip times for the Overload function is nominally 100 mS.
3. The trip times calculated from the above formulae are idealized. The trip calculations are executed every 20 mS, so there is an additional delay and uncertainty of 25 mS +/-15 mS.

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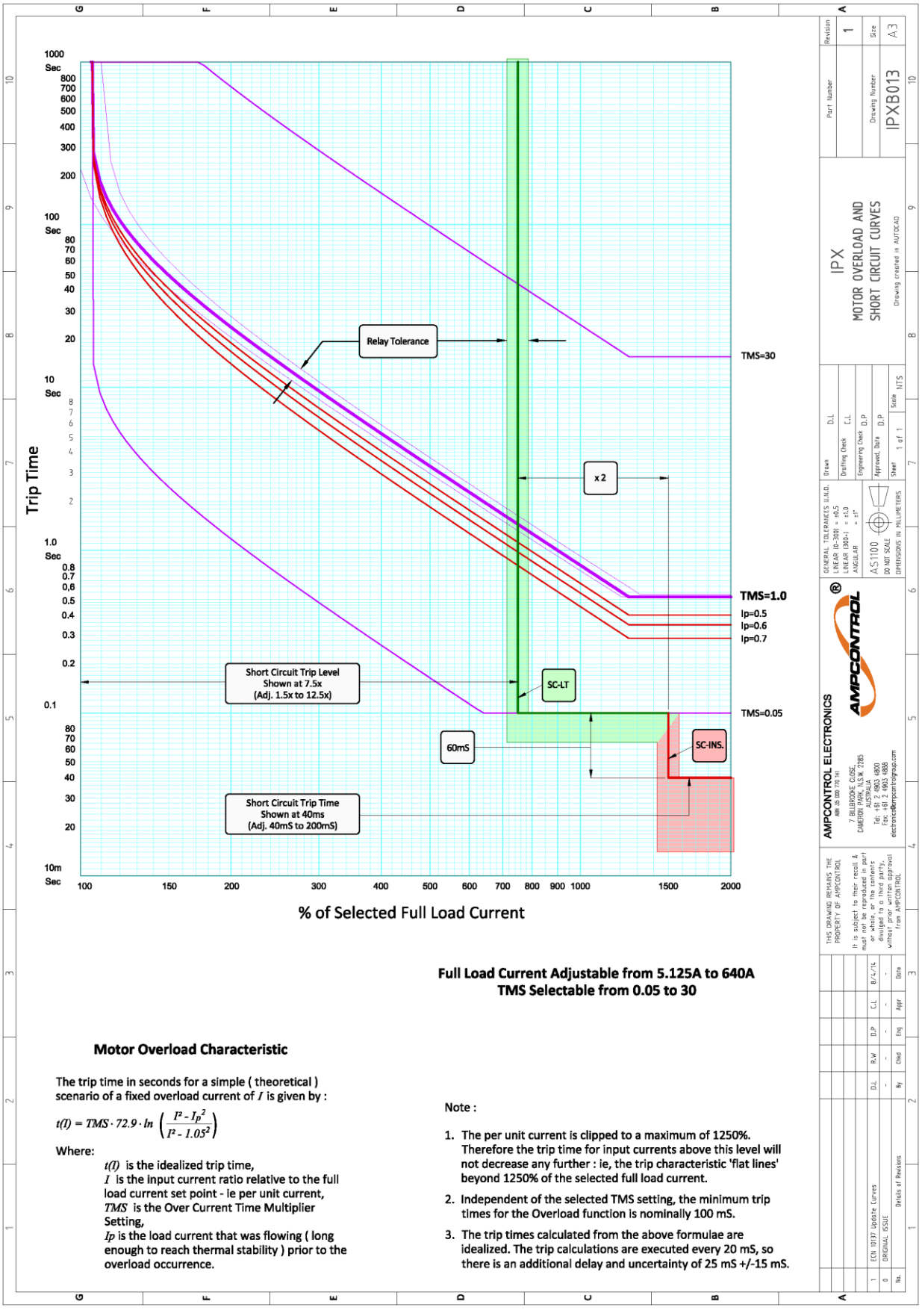

Full Load Current Adjustable from 5.125A to 640A
TMS Selectable from 0.05 to 30

Motor Overload Characteristic

The trip time in seconds for a simple (theoretical) scenario of a fixed overload current of I is given by :

$$t(I) = TMS \cdot 72.9 \cdot ln\left(\frac{I^2 - Ip^2}{I^2 - 1.05^2}\right)$$

Where:

$t(I)$ is the idealized trip time,
I is the input current ratio relative to the full load current set point - ie per unit current,
TMS is the Over Current Time Multiplier Setting,
Ip is the load current that was flowing (long enough to reach thermal stability) prior to the overload occurrence.

Note :

1. The per unit current is clipped to a maximum of 1250%. Therefore the trip time for input currents above this level will not decrease any further : ie, the trip characteristic 'flat lines' beyond 1250% of the selected full load current.
2. Independent of the selected TMS setting, the minimum trip times for the Overload function is nominally 100 mS.
3. The trip times calculated from the above formulae are idealized. The trip calculations are executed every 20 mS, so there is an additional delay and uncertainty of 25 mS +/-15 mS.

APPENDIX C: APPROVALS

This appendix contains a copy of Issue No. 0 of the IECEx ITA 12.0032X certificate of conformity and relevant attachments. For the most up-to-date copy of this certification refer to the http://iecex.iec.ch/ website.

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IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification Scheme for Explosive Atmospheres

for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.:	IECEx ITA 12.0032X issue No.: 0	Certificate history:
Status:	**Current**	
Date of Issue:	**2013-01-11** Page 1 of 4	
Applicant:	**Ampcontrol CSM Pty Ltd** 7, Billbrooke Close, Cameron Park, NSW, 2285 **Australia**	
Electrical Apparatus: *Optional accessory:*	**IPX Integrated Protection Relay System**	
Type of Protection:	**[Ex ia] I**	
Marking:	[Ex ia] I 0°C <Ta< 60°C. IECEx ITA 12.0032X	
Approved for issue on behalf of the IECEx Certification Body:	Parveen Akther	
Position:	Certification Authority	
Signature: *(for printed version)*		
Date:		

1. This certificate and schedule may only be reproduced in full.
2. This certificate is not transferable and remains the property of the issuing body.
3. The Status and authenticity of this certificate may be verified by visiting the Official IECEx Website.

Certificate issued by:

TUV Rheinland Australia Pty. Ltd
4 - 6 Second Street
Bowden SA 5007
Australia

TÜVRheinland®

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IECEx Certificate of Conformity

Certificate No.: IECEx ITA 12.0032X

Date of Issue: **2013-01-11** Issue No.: **0**

Manufacturer: **Ampcontrol CSM Pty ltd**
7, Billbrooke Close, Cameron Park, NSW Australia, 2285
Australia

Additional Manufacturing location (s):

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements. This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended.

STANDARDS:
The electrical apparatus and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards:

IEC 60079-0 : 2011 Explosive atmospheres - Part 0: General requirements
Edition: 6.0
IEC 60079-11 : 2011 Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"
Edition: 6.0

*This Certificate **does not** indicate compliance with electrical safety and performance requirements other than those expressly included in the Standards listed above.*

TEST & ASSESSMENT REPORTS:
A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in

Test Report:
AU/TA/ExTR13.0001/00 AU/TA/ExTR13.0002/00

Quality Assessment Report:

AU/TSA/QAR06.0007/05

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IECEx Certificate of Conformity

Certificate No.: IECEx ITA 12.0032X

Date of Issue: **2013-01-11** Issue No.: **0**

Schedule

EQUIPMENT:
Equipment and systems covered by this certificate are as follows:

The Integrated Protection Relay IS System Type IPX is designed to provide the necessary functions required for protecting electrical outlets in underground coal mines. These functions include earth leakage, earth continuity, earth fault and insulation failure lockout, over current, under voltage and contactor fail protection.

The IPX System comprises the following apparatus that are to be located in a non-hazardous (safe) area;
1. An Ampcontrol Integrated Protection Relay IPX and
2. An Ampcontrol RTX module

The IPX comprises three printed circuit boards upon which are mounted electronic components including a small battery for memory retention. The three printed circuit boards are designated
a. IPX Top PCB. The top board contains the majority of the intrinsically safe interface circuitry
b. IPX CCM PCB. The CCM board is a totally encapsulated board that comprises of a high voltage resistor chain and shunt connected voltage shunts that provide intrinsically safe connections to the high voltage source.
c. IPX Bottom PCB. The bottom board contains unspecified non-hazardous area circuitry.

The equipment is housed in a stainless steel enclosure and is fitted with terminal block mounted in the enclosure walls.

The IPX plugs into the IPX Base, which houses the HVR PCB. The HVR comprises of three high voltage resistor strings which connect to the high voltage via integral flying leads.

CONDITIONS OF CERTIFICATION: YES as shown below:

Special Conditions Applicable to this Certification exist and are availble for downloading as an Attachment to this Certificate on the IECEx Website www.iecex.com. and forms an integral part of this Certificate which must be read in conjunction with this Certificate.

These Special Conditions MUST be met and applied during installation and use of the IPX Integrated Relay Protective System.

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IECEx Certificate of Conformity

Certificate No.: IECEx ITA 12.0032X

Date of Issue: **2013-01-11** Issue No.: **0**

Page 4 of 4

EQUIPMENT(continued):

Drawing Asscoiated with the IPX Integrated Protective Relay System

Title:	Drawing No.:	Rev. Level:	Date:
IPX INTEGRATED PROTECTION RELAY CERTIFICATION MECHANICAL DETAILS	IPXA003Sheets 1 & 2	1	2012/11/14
MEM Top PCB	IPXB002Sheets 1 & 2	1	2012/11/30
CCM PCB	IPX-B-003Sheets 1 to 3	1	2012/11/19
* RTX	IPXB007	1	2012/11/30
IPX MEM Top PCB Pilot Interface Schematic	IPXE006Sheet 2 of 5	1	2012/11/1923
IPX MEM Top PCB Serial Interface Schematic	IPXE006Sheet 3 of 5	1	2012/11/1923
IPX MEM Top PCB Battery Circuit Schematic	IPXE006Sheet 4 of 5	1	2012/11/1923
IPX MEM CCM PCB Schematic	IPX-E-009Sheet 1 of 2	1	2012/11/1923
* IPX RTX IS Board	IPXE011	1	2012/11/1923
IPX I.S. System Diagram	IPXE014	1	2012/11/1923
IPX MEM Top PCB	IPXP002Sheets 2 to 4 of 5	1	2012/11/1923
Integrated Protection IPX CCM 1k – 3k3	IPX-P-003Sheets 1 to 4 of 4	1	2012/11/1923
IPX MEM HVR 1k – 3k3	IPXP004Sheets 2 to 3 of 4	1	2012/11/1923
*IPX RTX IS Board	IPXP008Sheets 2 to 4 of 5	1	2012/11/1923

* Indicates Drawings Associated with the RTX Module Covered by ExTR AU/ExTR/ITA/13.0001/00

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ATTACHMENT To IECEx CERTIFICATE
IECEx ITA 12.0032X

This Attachment forms an Integral Part of the IECEx Certificate and all pages MUST be presented and read whenever the IECEx ITA 12.0032X Certificate is presented

Special Conditions and Additional Information concerning the Ampcontrol IPX Integrated Protection Relay System

Special Conditions & System;
The following conditions of safe use must be applied in any installation:

1. Location of Apparatus
The IPX system comprises of an IPX Integrated Protection Relay Type IPX located in a non-hazardous (safe) area and a RTX module also located in a non-hazardous safe area and installed in strict accordance with the manufacturer's instructions. The interconnecting wiring passes through the hazardous area as part of a High Voltage pilot system

2. Input/Output Parameters
The following information must be taken into account during installation

a) Terminals 3 to 28
Um = 132 Vac RMS phase to earth

b) Flying leads
Um = 2286 Vrms phase to earth

c) Pilot & HV leads combined
The interconnecting cabling that connects the Pilot (Terminals 1 & 2) and the HV flying leads combined to the RTX Module must not exceed the following.

Capacitance (µF)	*Inductance OR Inductance to Resistance Ratio L/R*	
	(mH)	*Ratio* (µH/Ω)
3.72	4.5	207

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d) (Optional RDX) Terminals 29 to 33

The capacitance and either the inductance or the inductance to resistance (L/R) ratio of the hazardous area load connected the hazardous area connections must not exceed the following values;

Uo (V)	*Io* (mA)	*Po* (W)	*Co* (µF)	*Lo* (µH)	*L/R Ratio* (µH/Ω)
17.3	756	3.09	9.05	816	134

The above load parameters apply where;

i. The external circuit contains no combined lumped inductance (L_i) or lumped capacitance (C_i) greater than 1% of the above values. OR
ii. The external circuit contains either only lumped inductance (L_i) or lumped capacitance (C_i) in combination with a cable. OR
iii. The inductance and capacitance are distributed as in a cable.

In all other situations e.g. the external circuit contains combined lumped inductance and capacitance, up to 50% of each of the inductance and capacitance values are allowed.

3. A copy of drawings IPXE014 & IPXA003 Sheet 1 is to be provided to the user.

4. The chassis of the apparatus is to be connected to the intrinsically safe earth via suitable terminations complying with the requirements of IEC 60079-7 clause 4.2.

5. The installation is to be in accordance with the relevant installation Standards/Code of Practice and manufacturers drawing IPXE014. Careful consideration should be given when connecting the system to multiple earth points to prevent earth loops / potential differences between the different earth connections of the RTX and IPX units. This may be achieved by ensuring that all intrinsically safe earths are infallible connected to one point only.

6. The IPX module contains a small battery and protective circuitry that has been considered to comply with IEC 60079-0: 2011 & IEC60079-11:2011 only.

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ATTACHMENT To IECEx CERTIFICATE
IECEx ITA 12.0032X

This Attachment forms an Integral Part of the IECEx Certificate and all pages MUST be presented and read whenever the IECEx ITA 12.0032X Certificate is presented

Special Conditions Applicable to the RTX Module

1. Input/Output Parameters

Pilot/Earth (Connector J1)	
U_i=	28V
C_i=	18.8nF
L_i=	Negligible mH

All other connections (RTX I/O)
Are for connection to voltage free contacts/temperature sensors and suitable segregated from non-intrinsically safe circuits when the apparatus is considered to be Intrinsically safe.

2. The apparatus is not capable of withstanding a 500 V insulation test. This must be taken in to account in any installation.

3. Careful consideration should be given when connecting the system to multiple earth points to prevent earth loops / potential differences between the different earth connections of the RTX and IPX units. This may be achieved by ensuring that all intrinsically safe earths are infallible connected to one point only.

4. A copy of drawings IPXE014 & IPXA003 Sheet 1 is to be provided to the user

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